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COVER PICTURE

Woolbranding sheep as it
should be done—with the
animals held firmly in a
race, and with SI-RO-
MARR branding fluid

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AUTOMATIC WATERERS FOR DAY OLD CHICKENS

By P. SMETANA, B.Sc. (Agric.), and W. WARD, Field Officer, Poultry Branch

ONE of the most tedious and time consuming tasks on a poultry farm is the provision of water to chicks from day old up to the age of three or four weeks. Most poultry farmers use half-gallon glass fonts with metal bases for the first few weeks, until the chicks are old enough to use the automatic watering system usually situated along one wall of the brooder house. This cumbersome glass font system can be replaced by the cheap and easily installed automatic watering system described below. This system has already been adopted by several local poultry farmers.

Just before this year's chicken season, progressive Glen Forrest poultry farmer Mr. Ken Moore, noticed an advertisement for automatic chick waterers in an American poultry journal and decided to adopt a similar idea for his stock.

Mr. Moore has used this system, which we shall refer to as the "funnel system," on two large batches of chickens with complete success. Three other farmers have since installed similar systems, and all are highly satisfied with the results.

THE SYSTEM

The funnel system consists of a length of polythene pipe with plastic funnels fitted into it at one foot intervals. A cistern

with a float valve at one end of the pipe, and an outlet at the other end maintain the water level in the funnels.

Polythene piping is available at a cost of about 1s. 10d a foot. The four farmers using the funnel system have found one inch internal diameter piping to be satisfactory. The pipe runs the length of the brooder shed and is supported on short 3 in. by 2 in. blocks, to raise the level of the pipe from the cement floor to about the same height as the litter. This brings the funnels to a convenient drinking height for chickens.

The wooden blocks should be used at intervals of about two feet and the pipe clipped to every second block to avoid

Chicks using the funnel system set up for a continuous brooder. The brooder shed is 80 ft. long, and the drinkers extend over its entire length about 2 ft. from the brooder. The chicks never hop into the funnels and little dirt accumulates



twisting, which interferes with the correct placing of the funnels.

It has been found that 120 ft. of piping, running the entire length of the brooder shed, can be operated satisfactorily on one cistern.

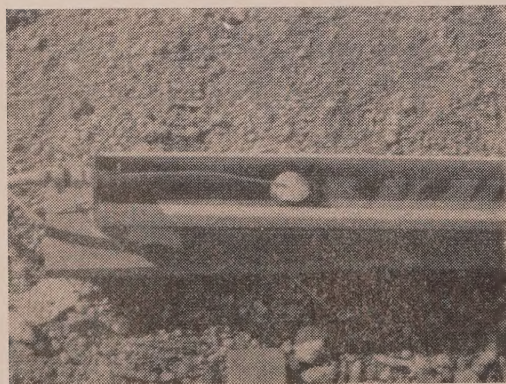
The pipe must be reasonably level throughout its length, so as to maintain a constant depth of water in the drinking funnels. If the floor of the shed is not level some packing should be placed under the wooden blocks.

To provide sufficient watering space for the chicks it was found necessary to space the funnels at one foot intervals along the entire length of the pipe. Funnels are of plastic and are approximately $2\frac{1}{2}$ inches deep with a short spout. They are available in a variety of colours from hardware stores, priced at about 10d. each.

Holes bored in the polythene pipe to take the funnels should be just big enough to give a neat fit with the spouts. This is simply done because the spouts are slightly tapered.

A plastic cement adhesive should be used to hold the funnels firmly in place. The spout of each funnel should be roughened before the adhesive is applied.

When the funnels are in place along the pipe, the cistern is installed at the inlet end and adjustments made to the cistern float to define the level of water in the funnels. For best results each funnel should be two-thirds full. If a ball float is used the cistern need only be about 2 ft. long by 8 in. wide and 8 in. deep. Where a Francis float is used an ordinary 3 ft. watering trough as illustrated will suffice.



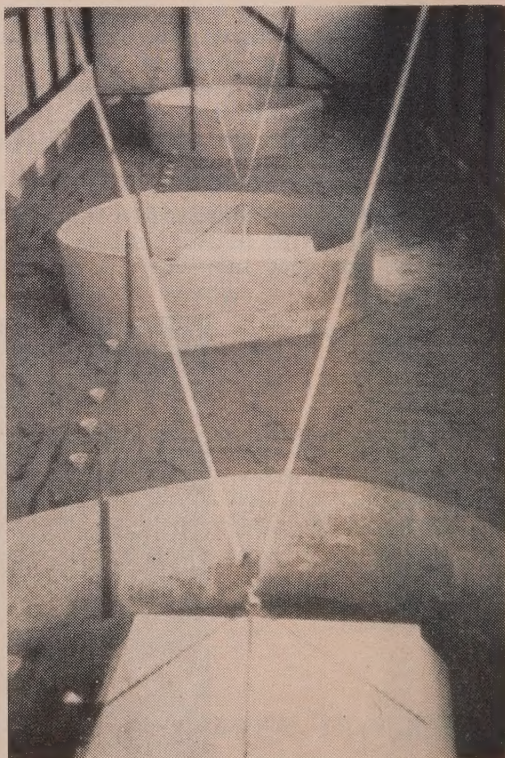
An ordinary three-foot watering trough with Francis float, which operates as a cistern for 80 ft. of polythene piping

The outlet end of the pipe should extend about two feet beyond the far end wall of the brooder house. This enables the end of the pipe to be lifted above the level of water in the cistern to retain the desired depth in the funnels. Alternatively, the pipe may be extended only a few inches and a plug inserted.

ADVANTAGES

This system of watering provides far less opportunity for dirt to collect in the waterers than the font or trough system. Some sawdust may accumulate from time to time, but this is easily flushed out either by removing the end plug or lowering the outlet end of the pipe. This rapidly flushes all dirt from the system.

The automatic system can be easily adapted to all types of brooding methods. If surrounds are used around individual brooders of about 200 chick size, at least four funnels can be included within this space at day-old. The number increases



The funnel system adapted to individual brooder units with metal surrounds

daily as the surrounds are expanded. In the case of a long continuous system of brooders all funnels can be used from day old.

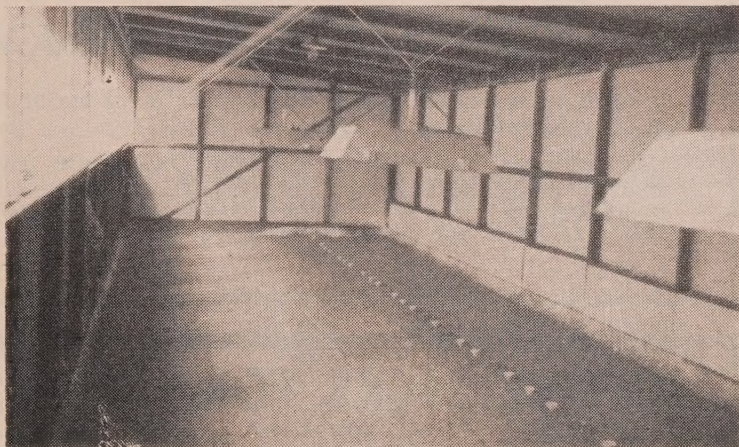
Chicks take to the funnel waterers immediately. On one farm they were noticed to use the funnels within three minutes of being placed under the brooder.

A calculation of actual costs showed that the initial outlay for this system was no greater than that for the glass fonts and metal bases generally used. Other costs are much lower.

The funnel system has operated with great success for chicks up to the age of four weeks. Normally by this age the birds have been switched over to the permanent automatic water troughs. When the funnel system is not in use the polythene pipe, complete with funnels, can be conveniently raised and suspended from the rafters in readiness for subsequent batches of chickens.

The funnel system is simple to instal in any brooder house, and because of the time-saving factor alone, should appreciably improve the efficiency of any farm.

The system set up in the brooder house awaiting arrival of the chicks. Electric brooders are suspended from the rafters



The outstanding advantage of the funnel system is the tremendous saving in labour. Once the funnel system is set up then no further attention is required apart from occasional flushing to remove dirt. With the font watering system, at least two half-gallon fonts should be provided for each 100 chicks, which means that 20 or more fonts must be kept filled for a batch of 1,000 chickens. This takes a great deal of time, particularly as the chicks get older. The chicken season is always a busy period for the poultry farmer so any device such as automatic watering which saves time is invaluable.

Another important advantage of the funnel system is that it facilitates medication through the drinking water. When medication is required a drum of medicated water can be attached to the intake of the cistern.

ACKNOWLEDGMENTS

We wish to express our thanks to Mr. and Mrs. K. Moore of Glen Forrest and Mr. and Mrs. J. Cameron of Kalamunda, whose enterprise and co-operation made this article possible.



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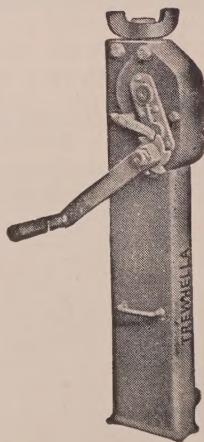
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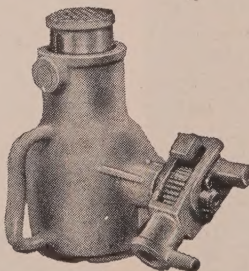
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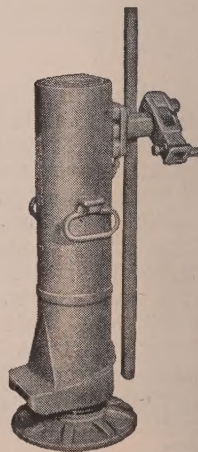
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Fossils and Farmers

The West Australian Museum is looking for fossil remains from the Pleistocene age, the period of geological time when Europe was covered with ice. Little is known of what the Australian continent was like at that time, and the Museum hopes, by collecting as many fossil remains as possible, to get a better picture of Australian conditions at that time. It is also hoped to discover more about the ancestors of our present marsupial fauna.

Farmers may be able to make a valuable contribution to the present knowledge of this period by forwarding suspected fossil remains to the Museum. Here the Museum's acting Curator of Palaeontology, Mr. D. Merrilees (B.Sc.) tells what to look for.

THE first illustration in this article is a comparison between the lower jaw of a large extinct marsupial known as *Nototherium* and the lower jaw of a modern wombat. Although very different in size, and belonging to different families of the Australian group of marsupials, nevertheless *Nototherium* and the wombat seem to have been rather alike in their sturdy build, blunt noses and vegetarian diet.

It is the purpose of this article to show how past generations of farmers have made it possible to issue a statement like this with some confidence, and to ask the present generation of farmers to carry on the work of their predecessors.

The connection between fossils and farmers is that farmers are better placed

than most other people to find fossils of the sort represented by *Nototherium*.

Nototherium belongs to that stretch of time known to geologists as Pleistocene time, or more familiarly, the Ice Age. It was during this time that great ice sheets spread out to cover much of the British Isles, Scandinavia, Canada and even into



The bone on the right is the fossil jawbone of an extinct marsupial. An idea of the size of this animal is given by the jawbone of a modern wombat, shown for comparison on the left



Most finds are only fragmentary, as shown by these fossil remains from Balladonia. At first glance these could be scraps of bone—but all are valuable fossils

Top left: Part of jaw of an extinct relative of present Tasmania devil

Top right: Part of single molar tooth of Diprotodon, an extinct marsupial of elephantine proportions

Lower left: Part of jaw of large extinct kangaroo

Lower right: Complete tooth of wombat, similar to the existing species

the United States. Mountainous regions throughout the world, including Kosciusko and central Tasmania, which now may have only relatively small valley glaciers or even only intermittent snow, then were capped with more or less continuous thick sheets of ice.

Geologically speaking, the Ice Age began very recently, under a million years ago. Since this period of time was geologically so recent, the animals living in it have left remains that are only shallowly buried, and sometimes not buried at all. It is for this reason that farmers, dealing as they do with relatively shallow layers of soil, but extending their operations over wide areas, are likely to come across Ice Age fossils.

A "fossil marsupial" is simply a piece of bone, probably broken, a stray tooth, or exceptionally a whole lower jaw, teeth and all, or a skull. Practically never does anything survive of hide or hair.

How is the farmer to recognise this stray tooth or piece of bone as anything out of the ordinary?

How does one distinguish between a horse tooth and a *Nototherium* tooth? Or between a sheep's thigh bone and the thigh bone of a marsupial wolf?

Sometimes the distinction may be made easily, but frequently it is not; the Museum therefore asks any farmer who has the remotest suspicion that a bone or tooth he has unearthed belongs to something

other than the ordinary domestic stock to send the specimen in for identification. By knowing what the specimen is and where it came from, we may discover new sites for known fossils, or even the remains of completely unknown animals.

At present, for the vast whole of Western Australia, we know of only a dozen or so places where Ice Age marsupial fossils have been found. There must be many more, and we appeal to farmers and to the rural community generally to help us find them.

Of the dozen or so sites at which Pleistocene marsupials have been found, some are in caves. Fortunately the Western Australian Naturalists' Club has an active cave exploration branch, and some very fine specimens have been brought in to the Museum in recent years by this group. Its activities have revealed, for example, that the present-day Tasmanian wolf and devil, now confined entirely to Tasmania, were once relatively common in our own South-West—and not so very long ago at that.

There are plenty of caves still to be investigated, and no doubt more good fossil deposits will be discovered in the future.

The remaining few fossils have been discovered by people sinking wells or making dams in various parts of the country. Such activities are always likely to unearth fossil deposits and the Museum must depend on individuals to report new discoveries.

Some very interesting finds have been made in recent years, and three of the best of these are worth mentioning for the light they throw on the general problem of collecting Pleistocene fossils.

First and most recently, a large bone unearthed by Mr. D. J. Moir, of Cape Riche, has defied the efforts of the combined Museum staff to name it or even to reach agreement on whether or not it came from a gigantic bird, quite unlike anything so far reported from Australia. Among other things, this example serves to point out the difficulties which even experienced people may have in dealing with fragmentary specimens from animals which may be both extinct and hitherto unknown.

Second, the *Nototherium* jaw illustrated (page 713) was discovered by Mr. H. White

of Merkanooka in the bed of the Murchison River. Failing to recognise the animal involved, Mr. White and his companions went to the trouble of digging the specimen out and trying to find out what it was. As a result of their trouble, this Museum now houses what is surely one of the most complete and most perfectly preserved specimens of this interesting animal in the whole of Australia.

Furthermore, because Mr. White reported an exact locality for his find, expeditions from the Museum have been able to go straight to the site and collect further specimens.

Finally, there is the case of *Balladonia*. Early settlers in this area, clearing out soaks round the bases of granite outcrops, found considerable quantities of bone they did not recognise. Unfortunately they did not always take the trouble to send these to the Museum. Through the courtesy of Messrs. W. Ponton, J. W. W. Graham and J. Sharp many years ago, enough specimens were retrieved to make *Balladonia* one of the two places in Western Australia where we have a good representative sample of the animals living here during the Ice Age.

The *Balladonia* specimens are hard and clean (although discoloured) and obviously impregnated with some substance which has served to preserve them. Once again, they are fragmentary, but this does not lessen their value in the scientific worker's eyes.

May I conclude by asking farmers to send in specimens about which they feel any uncertainty, together with a precise statement of the locality, and preferably with notes about the surrounding rock, depth of burial of the specimen, whether other specimens may be expected to be found and so on.

Specimens marked as such, consigned to the Director, Western Australian Museum, Perth, will be carried free of charge by courtesy of the Railways Department.

One way to earn a modest but honourable perpetuity for one's name is to have it inscribed as the finder of a specimen which may be examined a century hence by some earnest student of the Australian marsupials.

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ON THE DAIRY FARM

★

Seasonal Notes from the
Dairying Division

★

PLAN FOR QUALITY IN SILAGE



For best results most material should be wilted before storage. This is easily done where the buckrake is used (above). High moisture content is common in silage made by some modern equipment.

SILAGE making time is fast approaching in the South-West. Last minute preparations before harvesting will help avoid delays at the time of making this valuable fodder, thereby reducing the amount of costly spoilage caused by hold-ups.

Paddocks which have been closed up for silage should be looked over for stumps and rocks, and these marked; at the same time all wire, stones and other obstructions must be picked up so that they cannot cause breakdowns of valuable machinery during harvesting operations.

Before harvesting starts, check the tractor and other machinery to be used to make sure that all are in good working order and that any repairs or replacements are made before starting. Time lost while making silage means quality lost in the final product.

Selection of a suitable site for storing the silage is most important. The site should be well drained, convenient to the area being harvested, and suitable for getting machinery in for feeding out. Access for animals must be considered if self feeding is preferred.

Storage:

The overhead type of tub silo is not likely to be available on South-West dairy farms, and pit, clamp or stack storage sites must be selected.

To make high quality silage many requirements must be met. Therefore:

- Always select the best fields, as high quality material is required to produce high quality silage.

- Always cut the green material at the correct stage—that is, the early flowering stage of the main component.
- Don't close paddocks for too long before cutting, in an effort to get high yields. Early cutting and a high ratio of leaf to stem is required for the best results. Early cutting gives high quality silage, as well as good regrowth of pasture which can be kept for early summer dry feed or green grazing when most other fields have dried. If a paddock is protected from grazing for too long before cutting the result may be a heavy yield of stemmy, low quality material.
- To obtain best results, most material should be wilted before storage. The moisture content of good silage should not exceed 70 to 75 per cent. High moisture content is the rule rather than exception with silage made by modern equipment; it often has a moisture content above 80 per cent.

High moisture content silages often lose much of their soluble nutrient content as a result of drainage from the pit, clamp

or stack. Apart from this, wet green material is difficult to heat up in the early stages of silage making. Offensive smelling poor quality silage is often the result of storing such moist green material without prior wilting.

Where silage is to be held over the winter or stored for any great length of time, it is more than ever essential that the storage site should be well drained and the material covered to prevent rain damage.

With final sealing of the silage, good compaction is necessary and for best results sand or sawdust should be spread over the surface. This covering reduces external losses, which are often very high in poorly stored silage.

When making silage, see that all air pockets in the green material are excluded. When this material is finally rolled uniform packing is desirable; this can be efficiently done by tractor rolling.

ANTIBIOTICS SPOIL MILK FOR CHEESE MAKING

By K. NEEDHAM, B.Sc. (Agric.)

WHEN PENICILLIN is used for the treatment of mastitis, or is injected into the dairy cow for the treatment of any other form of disease, some of it finds its way into the milk supply. This residual penicillin in the milk is quite capable of destroying the bacteria added to milk in the process of manufacture of cheese.

If the rate of development of these organisms is retarded, the process of cheese manufacture is slowed down and the quality of the final product is likely to be impaired.

Both of these effects are harmful to the cheese industry as a whole, and if the condition was allowed to become widespread, could cause serious economic loss to the dairy industry.

Recent examinations by the Department of Agriculture's Dairy Laboratory have indicated that farmers are still sending milk to cheese factories containing levels of penicillin which are deleterious to good cheese manufacture.

It is in the interests of dairy farmers generally that when it is necessary to administer penicillin, either as an intra mammary infusion or as an injection, milk from treated animals should be withheld from the factory until 72 hours after the last administration.

A recent examination of cows injected with penicillin for control of footrot showed harmful levels of penicillin. It is possible that other antibiotics could have similar effects and it seems reasonable to suggest that similar restriction could be exercised as a general rule wherever antibiotics are used on dairy cattle.

The average dairy farmer is a busy man and it is possible that he might forget that certain cows have recently been treated. A dye has now been perfected which, when incorporated with penicillin used as an intra-mammary infusion, is secreted into the milk and gives it a distinctive colour. This colour is visible at levels of concentration of the antibiotic which are likely to be harmful to cheese manufacture.

This dye is not yet in general use, but it is hoped that it will be in the near future. It serves a very useful purpose, acting as a reminder to the dairy farmer, and alerting factory personnel to the presence of harmful antibiotics in the milk.

BREWERS' GRAIN CAN BE A USEFUL FODDER

CITY milk suppliers who are reasonably close to the brewery can make good use of brewers' grain as supplementary feed for their cows—but the grain needs to be handled and fed with care if it is to be really valuable.

Brewers' grain is the remains of the barley after malting, one of the first steps in beer making. Although it is a waste-product of brewing it retains considerable quantities of protein and carbohydrate. These make it valuable cattle fodder, particularly in times of feed shortage.

It is relatively cheap, but because of its high moisture content it does not pay to cart it long distances; furthermore, prolonged storage can cause spoilage when acid content rises and moulds form in the material.

Brewers' grain should be drained of excess moisture some hours before feeding. It may be fed at the rate of 20 to 30 lb. per head of the moist material with relative safety, provided that hay, silage or some pasture is included in the diet. With concentrates, a mixture of 4 lb. of the grain plus 1 lb. of concentrates can provide a reasonable diet.

As the material dries, palatability falls; some people mix in molasses to overcome this, but usually the effort is barely worth the added feeding value.

Here are two rations worked out for dried brewers' grain, each providing requirements sufficient for one cow's body maintenance plus production of two gallons of milk.

- (1) 20 lb. oaten hay.
6 lb. dried brewers' grain.
1 lb. meatmeal.
- (2) 40 lb. mixed silage.
12 lb. meadow hay.
8 lb. dried brewers' grain.
4 lb. bran.

If milk tainting occurs at any time through feeding brewers' grain the best policy is to feed only after milking, if this can be arranged.

USE YOUR TRACTOR SAFELY

In your own interests and for the sake of those dependent on you, observe at all times these simple rules drawn up by the National Safety Council of Australia in conjunction with the Tractor Trade Association of Australia:

- Read and act on maker's operating instructions.
- Before starting, put all controls in neutral.
- Never run engine in a closed building.
- Stop engine to service and fuel machine.
- Keep naked light or flame away from fuel.
- Wear close-fitting clothes.
- Keep steering and brakes in good order.
- Drive at safe speeds always.
- Don't snatch at loads—tractors can be overturned.
- Be careful on hillsides—tractors can be rolled over.
- Fit attachments correctly—avoid makeshift methods.
- Don't carry "joyriders"—especially children.
- Apply brakes and lower attachments before leaving.

Honey Flora Calendar for October

COMPILED BY R. S. COLEMAN, APICULTURAL SECTION, WITH ASSISTANCE FROM THE BOTANICAL BRANCH

Common Name	Botanical Name	Where Found	Honey		Quality of Pollen	Flowering Time	Remarks
			Quality	Quantity			
Parrot Bush	<i>Dryandra sessilis</i> (Knight) Domin. = <i>D. fortibunda</i>	Widespread, seems to prefer shallow soils	Medium	Excellent	Good	Mid July-mid Oct.	It is the highest yielder of honey outside the eucalypts. Produces best in milder areas along the coast on limestone hills. Should be just finishing in southern areas.
Brown Mallet	<i>E. astrinens</i> Maiden	Ravensthorpe and Southern Districts	Good	Good	Good	Oct.-Nov.	Mainly found in plantations because of heavy cutting of natural forest for bark. The bark is used for tanning. The honey is like York Gum honey. About 4 years between flowering, has just flowered in 1960.
York Gum	<i>E. laxophleba</i> Benth.	Widespread throughout the State. It is found in wide belt from north of Northampton to Salmon Gums	Good medium amber. Candles with a fine grain	Very good	Very poor	Flowers over a long time but main producing period is Oct.-Dec.	One of the main honey flows. Falls sometimes for unknown reasons. Budded in patches for 1961.
Wild Hop	<i>Chorilaena hirsuta</i> Benth.	Karri forest	Fair	Good-fair	Good	Sept.-Dec.	Bees can work it in the rain as the flowers are pendant. Associated with the Soap Bush to form the Hazel thickets of the Karri forest.
Soap Bush	<i>Trypsalma spathulatum</i> (Labill.) Ostf.	Karri forest and coastal plain	Fair. It has a somewhat fade taste	Good	Good	Sept.-Dec.	Soap Bush and Wild Hop form the Hazel thickets of the Karri Forest.
Diamond Bush	<i>Bessia laidiawiana</i> Tovey et Morris	Gravelly soils and creek banks. Common in Karri forest	Good	Good	Excellent	End of Sept.-Nov.	One of the best pollen supplies in the State. It is believed to be the plant that causes the bees to swarm excessively.
Taylorina	<i>Psoralea pinnata</i> Linn.	Swamps in Albany-Denmark area	Excellent white	Good	Good	Sept.-Nov.	Introduced plant.
Salvation Jane, Patersons Curse, Vipers Bugloss	<i>Echium plantagineum</i> Linn.	Weed of agricultural areas	Excellent	Excellent	Excellent	Spring Nov. Oct.	Apparently needs a wet winter to produce.
Flooded Gum	<i>Eucalyptus radix</i> Endl.	Wetter areas along water-courses	Good	Good	Good	Mid Aug. to beginning Nov.	Good strength building flow and if bees strong enough in the beginning will give two or more extractions

THE OPEN RANGE SYSTEM OF PIG RAISING

By S. R. DUNSTAN, M.D.A., Technician, Dairying Division

THERE are several satisfactory systems which can be employed in planning a piggery, but under West Australian conditions, the paddock system has much to commend it. Grazing admits an animal to the healthy influences of sunlight and stimulates exercise. The digestive processes of the pig are also stimulated and this helps to bring about more efficient utilisation of the feed.

When locating a site for a piggery, it is advisable to select a well-drained area, not too close to buildings and yards. Regulations state that on dairy farms, the piggery should be situated at least 200 feet away from any milking shed, milk room or dairy.

With a heavy concentration of pigs over a long period, land eventually becomes "pig sick," and from the disease and husbandry point of view, it is desirable to use a layout on which the build up of worm egg and disease-causing organisms can be controlled. To overcome this difficulty the paddocks should be large enough to permit cultivation with modern implements, and sufficient paddocks should be provided to permit a rotation of at least four weeks or longer.

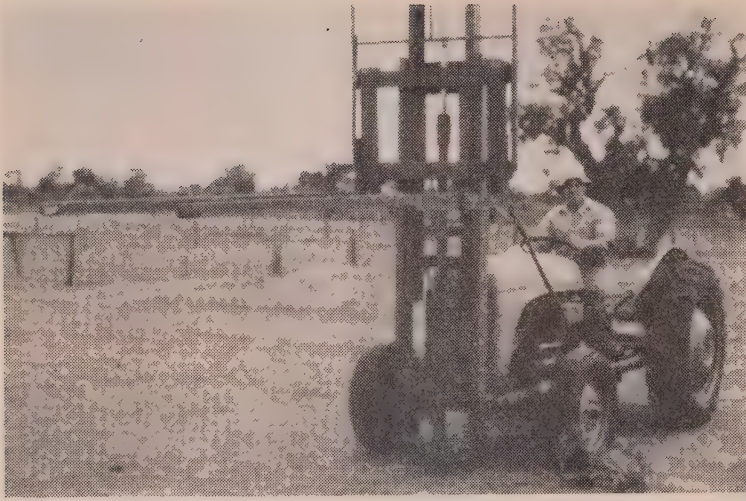
The land should be cropped during the resting period, and the greenfeed which becomes available is a supplement to the pigs' diet. Greenfeed is a valuable source of Vitamin A, which is frequently deficient

in the diet of pigs, especially pregnant sows. Good quality pasture is also a valuable source of protein, and under good conditions can replace up to half of the meatmeal requirements of pigs over the suckling stage. Greenfeed alone is unsatisfactory for pigs because they are not ruminants and have a small type of stomach similar to that in humans; therefore, they require a concentrated type of food such as crushed grain, and a protein supplement. For the efficient utilisation of the feed, and to supply the "animal protein factor" deficient in other feeds, it is essential to supply some protein of animal origin.

Compared with an intensive system of raising the open range has the advantages of considerable savings, not only in feeding, but also in labour costs, as under grazing there is no cleaning out and removal of dung from the pens.



Pigs grazing on the open range system. In the background are portable shelters



A good type of lift used for transporting portable shelters under open range conditions.

During the summer months it is important to provide adequate cooling facilities for the pigs, otherwise they will be uncomfortable, will eat less and therefore gain weight much slower than they otherwise might. Therefore, adequate shade and an easy access to an abundant and cool water supply should be provided, especially when white coloured pigs are raised. In all localities the provision of a cement wallow, or a spray system to cool the pens, would be a great advantage, but a badly drained and boggy pig yard does not constitute a wallow and is a breeding ground for disease. If shade is the only means of cooling the pigs, the trees should be protected from ringbarking by surrounding them with barbed wire.

The paddock system is very satisfactory providing there is adequate efficient fencing and the land is not overstocked, eventually to become a barren dustbowl. Even when a rotation is practised on a piggery under open range the stocking rate should not exceed two large sows and their progeny per acre or the equivalent in smaller pigs, and under most conditions, the stocking rate should be much lighter.

Under free-ranging conditions healthier animals may be produced with less trouble, and at reduced cost. It is, however, still necessary to provide shade and dry, water-proof shelters for best results. These may be portable if desired.

TWINS FROM EIGHT-YEAR-OLD SEMEN

The birth of twin heifer calves on a farm in Suffolk, from a cow inseminated with semen deep-frozen since 1952, is believed to be a world record in insemination.

The twins are the progeny of a British Friesland bull which stood at the Cambridge A.I. centre and died in 1956. The owner of the farm has just had 14 calves (six bulls and eight heifers) from 13 cows served with the last 13 ampoules of the season. He is rearing one of the bulls for the Cambridge A.I. centre.

PULLORUM TESTED POULTRY FLOCKS, 1961

THIS year's pullorum tests of poultry flocks have revealed the lowest incidence of reactors since the tests began. Results are recorded below.

Early in 1955, an amendment to the Stock Diseases Act made blood-testing compulsory for all commercial breeding and hatchery flocks of poultry. It was required that the incidence of infection, as determined by the last test before the commencement of hatching, must be less than two per cent.

For the seven years 1948-54 when blood-testing was on a voluntary basis the average percentages of reactors were 5.43; 5.65; 5.95; 3.37; 2.53; 1.36 and 0.77 respectively.

This year's test showed an average reaction of only 0.14 per cent.—the lowest figure to be recorded. The 1960 figure was 0.19 per cent.

Only 189 reactors were found in a total of 130,867 birds tested and 37 of the 71 flocks tested were free of reactors. Only one flock had to be tested twice.

All chicks sold in Western Australia must be hatched from eggs derived from pullorum-tested stock.

The breeds of poultry in the various flocks are indicated by the following abbreviations:—

Australorp, A; White Leghorn, WL; First Cross, XB; Rhode Island Red, RIR; Light Sussex, LS; Langshan, L; New Hampshire, NH; various breeds VB; Meat Breed, MB; Plymouth Rock PR.

Name and Address	Breeds	No. of Birds Tested	Percentage of Reactors
Adams, W. T., Bullsbrook ...	A, WL	3,478	0.17
Anderson, P., King Edward Road, Osborne Park	A, WL, XB	1,295	...
Angel, L., Mt. Helena	A, WL	2,557	0.14
Barker, G., Widgee Road, Morley Park	MB	3,274	...
Barnett, T., Cowaramup	A, WL	379	...
Bell, C. J., Grand Promenade, Bedford Park	A, WL, XB, MB	2,561	0.14
Bell, N. A., Abernethy Road, Cloverdale	A, WL, XB, MB, RIR	8,919	0.06
Bloomfield, H., Great Eastern Highway, Northam	A, WL, RIR	386	...
Caporn, A., South Coogee	A, WL	400	0.75
Carter, R. J. & N. H., Eva Street, Maddington	WL	791	...
Catherall, W. H. & G. E. F., Taylor Street, Maida Vale	A, WL, XB	1,394	...
Chalmers, F. E., Ancanthus Road, Riverton	A, WL	1,710	0.58

Name and Address	Breeds	No. of Birds Tested	Percentage of Reactors
Chalmers, H., Ancanthus Road, Riverton	WL	1,811	...
Charlton, A., Spring Road, Kenwick	A, WL, XB	5,780	...
Chadwick, F., Narrogin	A	640	...
Cole, B., Railway Avenue, Kelmscott	A	608	...
Cole, H., Division Street, Welshpool	A, WL	1,283	...
Cook, W. A., Welshpool Road, Welshpool	A, WL, XB	2,595	...
Collins, H., Epsom Avenue, Redcliffe	A, WL, NH, RIR, PR, L	1,021	0.01
Conlon, T., Troy Street, Basendean	A, WL	538	...
Dabelstein, E. T., Ypres Road, Kelmscott	A, WL, RIR	1,625	0.06
Dadley, M. H., Rockingham Road, South Coogee	WL	1,040	...
Davey, A. E. & I., Eleventh Road, Armadale	A, WL	3,301	0.39
Davey, A. G., Mundijong	A, WL, VB	2,190	0.23
Dempster, F., Wanneroo Road, Wanneroo	A, WL, XB	1,441	0.21
Diamond Farm, Wanneroo	MB	1,484	...
Elvish, R., Helm Street, Maddington	XB	1,445	...
Fawkes, M., Wyatt Road, Bayswater	A, WL, MB	4,918	0.86
Fenton, J., North Lake Road, Melville	A, WL, RIR	2,624	...
Gardiner, C., Division Street, Welshpool	A, WL, XB, RIR	1,517	0.20
Gates, A. S., King Edward Road, Osborne Park	A, WL, XB	1,938	...
Hampton, A., Scott Street, Kewdale	A, WL, MB, LS	12,945	0.07
Hall, J. A., Wharf Street, Queens Park	A, WL, XB	1,003	0.10
Hedges, J., President Street, Kewdale	A, WL	1,170	0.20
Heggie, L., Wanneroo Road, Wanneroo	A, WL, MB	3,295	...
Hill, R., Widgee Road, Morley Park	A, WL, NH, RIR	1,854	0.05
Hickson, R., Amherst Road, Swan View	A, WL	854	0.30
Hoult, B., Kalamunda Road, Maida Vale	A, WL	1,947	...
Hugall, T. G., Kalamunda Road, Maida Vale	A, WL	473	0.60
Hunter Bros., Oats Street, Kewdale	A, WL	2,143	...
Keene, K., Great Eastern Highway, Redcliffe	A, WL, NH	1,895	0.21
Kendall, L., Victoria Street, Guildford	A, RIR	194	...
Kirwin, F., Nisbet Street, Belmont	LS	42	...
Mercer, B. M., Gnanagara Road, Wanneroo	A, WL	422	0.23
Miles, R., Wanneroo Road, Wanneroo	A, WL, MB, LS	2,823	0.24
McAuliffe, K., Katanning	A, WL	109	0.91
McGregor, E. M., Cranium Street, Kewdale	A, WL	1,720	...
McGrath, W., May Street, Kewdale	A, MB	721	0.14
Oliver, R. E., Welshpool Road, Welshpool	A, WL	1,160	...
Oughton, A. W., Maida Vale Road, Forrestfield	A, WL	872	...
Parin, A., Wanneroo	A, WL	1,492	...
Pierce, P. C., Kenmore Avenue, Bayswater	A, WL	432	...
Porter, R., Kingsway Road, Wanneroo	A, WL, XB	1,423	0.21

Name and Address	Breeds	No. of Birds Tested	Percentage of Reactors
Porter, L. S., Narrogin	A, WL	2,668	0-18
Potter, S., Katanning	A, WL	381	0-52
Reid, J., President Street, Kewdale	A, WL	1,134	....
Roberts, S. G., Cohn Street, Carlisle	A, WL	2,427	0-50
Sears, G., Wanneroo Road, Wanneroo	A, WL	2,252	....
Singleton, E., Jandakot	A, WL	411	0-48
Stevens, J. H., Swan Street, Guildford	A, WL, RIR	1,919	0-90
Smith, J. T., Lionel Road, Darlington	A, WL, XB	1,937	....
Spackman, R. J., Keymer Street, Belmont	VB	38	....
Swannell, K. A., Macedonia Street, Naval Base	WL	1,320	....
Tyler, A., Beechboro Road, Bayswater	A, WL	1,672	....
Upson & Son, Pemberton	A, WL	1,272	....
Wear, R., Kew Street, Kewdale	A	43	....
Webb, A. S., Maida Vale Road, Maida Vale	RIR	186	0-50
Whittaker, C. E., Yale Road, Kenwick	A, WL	2,276	0-13
Woodard, H., Hughes Street, Canning Vale	A, WL	2,948	....
Woodard, L., George Street, Queens Park	A, WL, XB	2,644	0-11
Yates, A., Fulham Street, Cloverdale	A, WL, XB	1,403	0-04
Total ....	....	130,867	0-14

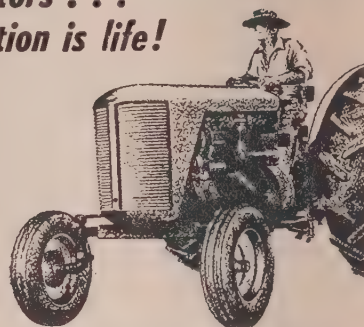
Y.A.L. TOURS

During the forthcoming Christmas-New Year holidays, tours and excursions have been arranged by the Young Australian League for both boys and girls. The Boys' Interstate Tour commences Saturday, December 30th. The party will fly direct from Perth to Melbourne and after six days in Melbourne where visits will be made to Ballarat and the Dandenong Ranges, will go by rail to the Snowy Mountains where trips will be made to Tumut 1 and 2 Power Stations, as well as Guthega Dam, Lake Eucumbene, and Mt. Kosciusko. In Canberra the party will visit Federal Parliament House as well as the Australian War Memorial and "Yarralumla."

The group will then travel by rail through to Brisbane, visit the fabulous Gold Coast, as well as the Oasis, and Mt. Coot-tha, and from Brisbane the party will then return to Sydney where excursions will be conducted to Katoomba in the Blue Mountains, Gosford in the heart of the citrus-growing district, as well as Taronga Park Zoo, Manly, and a boat trip on the Harbour.

Prospectus giving details and information in connection with the above tours is available at the Y.A.L. Office, Murray Street, Perth, or any Branch of the Commonwealth Savings Bank.

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TREES

of Western Australia

By C. A. GÄRDNER

No. 91—THE POWDER BARKED WANDOO

(*Eucalyptus accedens*—W. V. Fitzg.)

THIS species was originally named by W. V. Fitzgerald from specimens which he obtained from near Pingelly in November, 1903. The name *accedens* is from the Latin *accedo*—to approach or come near—and is here used in reference to the supposed close approach of the tree to the common wandoo (*Eucalyptus redunca* var. *elata*).

The two trees are, however, very dissimilar botanically, and any resemblance, or close approach would refer to the habit of growth and the character of the bark, in which they are not dissimilar.

They can be easily distinguished in the field by the character of the bark, which in the wandoo is white in colour except in those forms which we find eastwards from Tammin; but the bark is never powdery, and the timber is a pale yellow ochre in colour. In the powder barked wandoo the bark has a talc-like powder always in evidence at least on the protected or eastern side of the trunk; it is yellow in fracture, and the timber is more pink in colour.

Furthermore, the two trees almost always occur in different soil types, the wandoo in clay, and the powder-barked wandoo associated with laterite on high ground. Thus we find it not infrequently in the Darling Range on high lateritic hills, often growing amongst boulders of laterite.

Almost if not all of our gum trees—at least those species of *Eucalyptus* with a smooth bark—shed the outer layers of their bark annually, usually between February and the early part of April, and the newly exposed bark is as a rule much deeper in colour than it appears later in the year when it pales considerably. For example, the karri bark is a deep orange at this time of the year, and the wandoo has a warmer tint in April than later in the year, when it often assumes a dead white colour. The powder-barked wandoo is never this pale or white colour, and retains something of its orange-red tint throughout the year. As it is often flecked with small patches of older persistent outer bark, it is not uncommonly known as “spotted gum” especially in the York and Pingelly districts.

Botanically the powder-barked wandoo can be distinguished by its usually broader foliage, the peduncles not distinctly flattened as in the wandoo, the fewer flowers of the umbels, and the much shorter obtuse hemispherical to ovoid bud cap (operculum). In the wandoo many of the filaments are erect when in the bud stage, but in the powder-barked wandoo they are all incurved. The fruits are also more pear-shaped and contracted at the top.

The powder-barked wandoo extends from Arrino in the north to Pingelly and Dwarda in the south, and eastwards to Werribee, Coates Siding, Cut Hill (near York), and Pingelly. It is also fairly common between Mogumber and Bindoon. It flowers in the early summer.

The form collected on Mount Peron, illustrated on the accompanying plate, is somewhat different to the common form.



THE POWDER BARKED WANDOO
Eucalyptus accedens—W. V. Fitzgerald

A—Branchlet with flower buds; B—Flower buds; C—Flower bud; D—Anthers; E—Fruits; G—Section of fruit; H—Cotyledons; I—Flower buds; K—Fruit. (B-K enlarged.) A-H, Wooroloo, F. M. Schoch; I-K, Mount Peron; Gardner 9412 (buds and fruits).

THE DONGARA MALLEE
Eucalyptus dongarraensis—Maiden and Blakely.

L—Flower buds; M—Fruits; N—Section of fruit; O—Seeds. (All enlarged.) Dongara, Gardner s.n..

No. 92—THE DONGARA MALLEE

(*Eucalyptus dongarraensis*—Maiden and Blakely)

THE originally described specimen of a species is known as the type specimen and is that which is used where possible for comparison with material collected later. Sometimes the type specimen is far from typical of the population which is the species, especially when this type specimen comes from the boundary of the known range of the species.

For example, *Eucalyptus comitae-vallis*, previously dealt with in this series, was named from material collected near Comet Vale. The distribution extends from Kulja eastwards, and the western form was later described as *Eucalyptus brachycorys*. The common or typical form of the species is intermediate in character between the two.

Similarly *Eucalyptus dongarraensis* was described, as the name implies, from material which Maiden collected at Dongara. The species extends eastwards (at least as far as Yuna) and southwards, but just how far I do not know. It appears to be a variable species inhabiting a variety of soil types, usually a light loamy or gravelly soil, while the Dongara form grows in white sand.

The species varies from a mallee to a small tree with a ribbony bark in the lower part of the trunk, but white and smooth upwards, with reddish branchlets. The buds and fruits are much like those of *Eucalyptus accedens*, but the operculum is obtusely ribbed or wrinkled (at least in the dry state) and it is also usually shorter. The fruits are smaller and more cupular in shape and approach the Mount Peron form of *Eucalyptus accedens*. In the tree form the timber is described as being dark in colour.

The relationship between the two forms is receiving further attention.

Eucalyptus dongarraensis has been collected from north of Galena and from Dongara, Mullewa, Yuna and Walebing.

No. 93—THE MESSMATE OR STRINGYBARK

(*Eucalyptus tetrodonta*—F. Muell.)

THIS tree is widely spread over the higher rainfall regions of Northern Australia. In the Kimberleys it is found fairly widely diffused over the sandstone and quartzite country to the north of the King Leopold Range, and eastwards on the Cockatoo Sands of the lower Ord River.

It is a common tree of the Edkins Range and the country between the Prince Regent and Glenelg rivers, the Phillips Range and eastwards to the Durack River, usually growing on the lighter soils in the valleys. Sometimes known as stringybark, the tree is more familiarly called messmate by those early settlers who came over from Queensland in the last century.

It attains a height of 60 feet, with a trunk up to two feet in diameter. The bark is rough throughout, grey in colour, and has a fibrous, stringy persistent quality. The red timber is not unlike that of the jarrah tree, but less hard and dense and somewhat paler in colour.

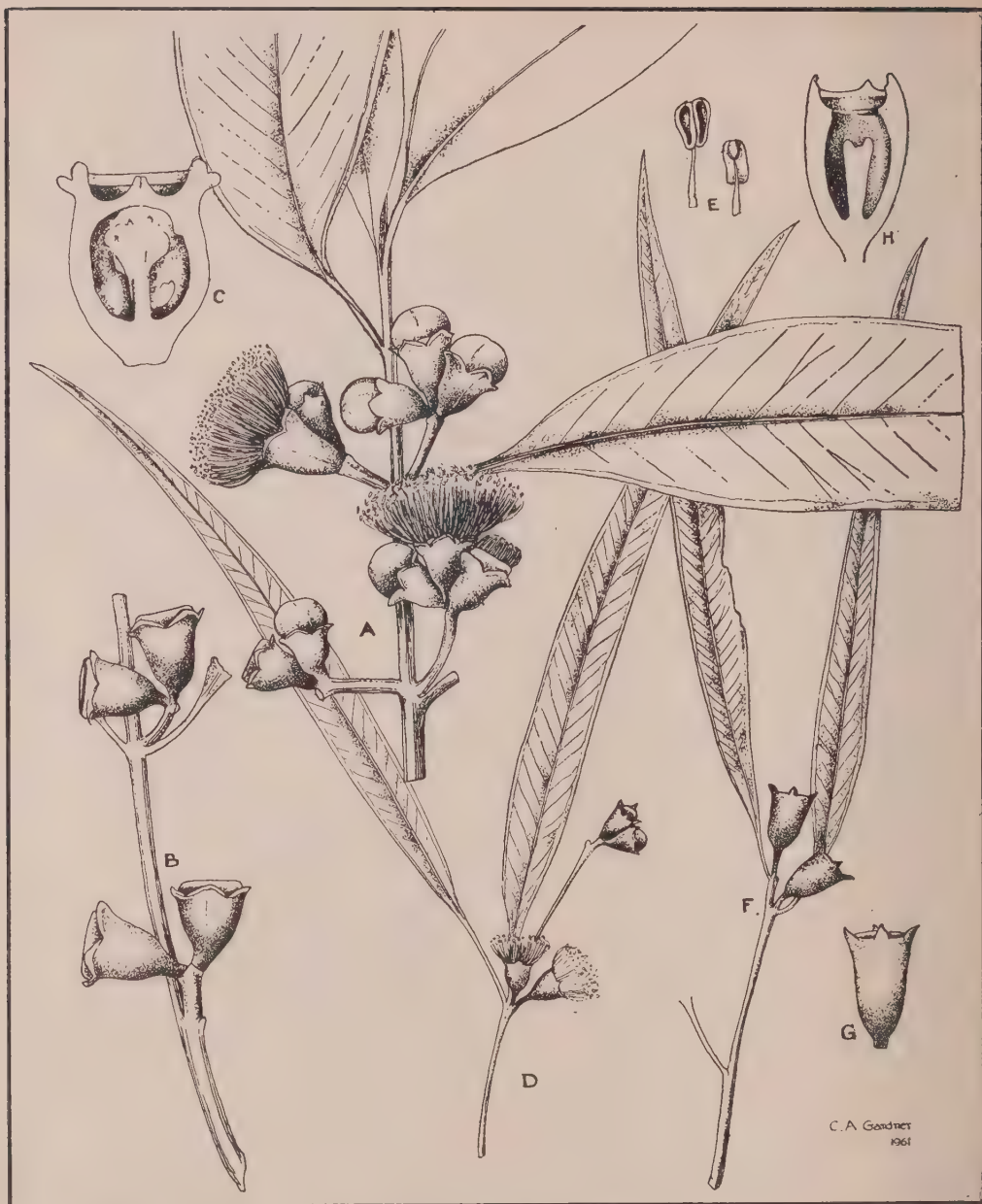
The leaves are a dull green, up to eight inches long, very variable in width, with a strong midrib and faint lateral nerves, the intramarginal nerve being separate from the leaf-margin.

The white flowers are in umbels each consisting of three almost stalkless flowers. The calyx-tube or hypanthium is bell-shaped, with four broad conspicuous lobes or teeth below the rim, and is smooth or ribbed. The operculum or bud-cap is hemispherical, and either quite smooth or four- or eight-ribbed. The stamens are not in bundles but in a continuous series or ring, and the versatile oblong anthers open in distinct longitudinal slits.

The fruits are bell-shaped, shortly stalked, smooth or four-ribbed, with the persisting teeth of the flowering stage, the rim projecting beyond them. The three valves by which the fruits open are not extended beyond the rim of the fruit.

The tree flowers from March to June.

We have seven species of *Eucalyptus* which possess teeth on the calyx; of these four are found in the south, and the stamens are in four clusters or bundles;



THE MESSMATE OR STRINGYBARK
Eucalyptus tetrodonta—F. Muell.

A—Branchlet with buds and flowers; B—Fruits; C—Section of fruit. Mount Shadforth, Edkins Range, Gardner 1075.

THE STURT CREEK MALLEE
Eucalyptus odontocarpa—F. Muell.

D—Branchlet with flower buds and flowers; E—Anthers; F—Branchlet with fruits; G—Fruit (enlarged); H—Fruit in section (enlarged). Boundary Survey, between 18° and 19° Lat. S., S. J. Stokes.

the three tropical species have the stamens not in bundles, but in a continuous ring.

The timber of the messmate is used by pastoralists, but unlike the jarrah (which it resembles), is not immune to termite attacks.

No. 94—THE STURT CREEK MALLEE

(*Eucalyptus odontocarpa*—F. Muell.)

THE specific name of the Sturt Creek mallee is derived from the Greek *odontos*, a tooth, and *karpos*, fruit, in reference to the small tooth-like lobes of the hypanthium.

The Sturt Creek mallee attains a height of 12 feet, but is usually of less stature. It grows in stony hills in an arid environment, and is but little known. The writer has seen it on the rough country of the upper reaches of the Ord River, where it has slender smooth-barked stems and narrow pale-coloured leaves.

The flowers are small and white, and the species can be readily recognised by its opposite leaves, narrow buds and fruits with four small acute but prominent teeth, somewhat spreading. The operculum is much like that of the messmate, to which *E. odontocarpa* is closely related, and the stamens are in a continuous ring as in that species. The flowers are in shortly stalked clusters of two or three, or solitary, on short slender stalks.

The fruit is much narrower than in the messmate. Unlike the latter however, the operculum does not exceed the calyx-teeth, and is hemispherical to almost patelliform.

This little known mallee is common in the Northern Territory on the cliffs of the Victoria River and in the dry spinifex country to the South. In Western Australia we have it only from the vicinity of the upper Ord River and eastwards, and the desert country of the upper Oakover River. Mueller collected it in the desert of Sturt Creek in 1856; Fitzgerald found it in West Kimberley, and a specimen collected on the upper Oakover River by R. D. Royce completes our knowledge of this species in Western Australia.

MURESK AGRICULTURAL COLLEGE

(Department of Agriculture)

Parents are reminded that applications for 1963 admission to Muresk Agricultural College close on December 31 of this year. A preliminary selection of 1963 entrants is made after the Junior results are available early in 1962.

The successful applicants then continue with Sub-Leaving, or higher studies, in 1962.

Before the course can be commenced students must have attained:—

- (a) Sub-Leaving Standard in English, Maths. A, Chemistry and Physics (including Magnetism and Electricity if possible).
- (b) Junior Standard Bookkeeping.

Should places still exist for 1963 commencement after the preliminary selection early in 1962, they are filled in order of application during 1962, by qualified applicants.

Duration of Course.—Two years.

Fees.—Approximately £185 per annum covering full residential charges.

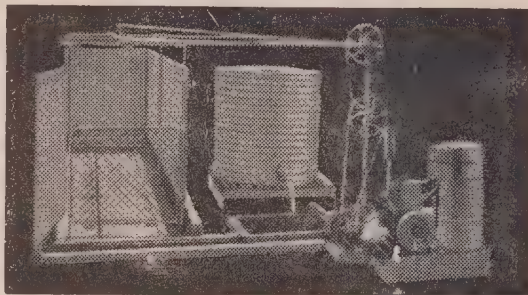
Scholarships.—Department of Agriculture (3), the "Countryman," and J. J. Poynton Memorial (2).

Boarding Allowance.—Most Muresk students are eligible for the Education Department Boarding Allowance (£50 per annum).

Full details of the College are obtainable from the Principal, Muresk Agricultural College, Muresk, W.A., or the Department of Agriculture, Perth.

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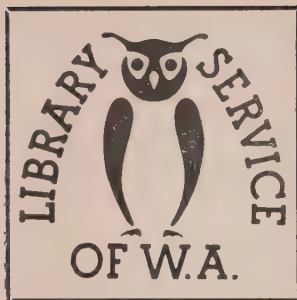


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BOOKS...

for FARMERS

THE following books on agriculture, recently published and obtainable to order from most booksellers, have been added to the stock of the Library Board of W.A. and may be borrowed freely from any public library associated with the Board, or consulted at the State Library of Western Australia.

GENERAL

AGRICULTURAL CO-OPERATION IN THE UNITED KINGDOM; by M. Digby and S. Gorst. Oxford, 1957.

PROCEEDINGS OF THE 1st NEW ZEALAND AGRICULTURAL AVIATION SYMPOSIUM, 1959. Wanganui, 1959.

YOUNG FARMERS' CLUBS IN SCHOOLS; by G. Badman and the Staff of the National Federation of Young Farmers' Clubs, with additional material by Phyllis Pearce, Lester Betts and Sean McB. Carson. Lond., 1960.

FARM MANAGEMENT

FARM ORGANIZATION AND MANAGEMENT; by G. Hayes. Lond., 1959.

AGRICULTURAL MACHINERY

FARM MECHANICS TEXT AND HANDBOOK; by L. J. Phipps, H. F. McColly, L. L. Scranton, and G. C. Cook. Danville (Ill.), 1959.

USING ELECTRICITY ON THE FARM; by J. R. Hamilton. Englewood Cliffs (N.J.), 1959.

SOILS AND FERTILISERS

A MANUAL OF SOIL FUNGI; by J. C. Gilman. 2nd Rev. Ed. Ames (Iowa), 1957.

NUTRITION OF THE LEGUMES; proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958; edited by E. G. Hallsworth. Lond., 1958.

PROCEEDINGS OF EXTENSION SCHOOL IN SOIL SCIENCE, held at the University of New England, February 10-14, 1958, by the Department of Adult Education. [Armidale (N.S.W.), 1958.]

DISEASES AND PESTS

INSECT RESISTANCE IN CROP PLANTS; by R. H. Painter. N.Y., 1951.

MODERN INSECTICIDES AND WORLD FOOD PRODUCTION; by F. A. Gunther and L. R. Jeppson. Lond., 1960.

PROCEEDINGS OF A RABBIT CONTROL SYMPOSIUM, held in Sydney, 1960; convened by C.S.I.R.O. Melb., 1961.

REPORT OF THE 3rd CONFERENCE OF COMMONWEALTH AND STATE ENTOMOLOGISTS, 1959. Melb., 1960.

FIELD CROPS

JAPONICA RICE; its breeding and culture; by I. Nagai. Tokyo, 1959.

PROCEEDINGS OF A SYMPOSIUM ON COTTONSEED AND ITS BY-PRODUCTS, held in Hyderabad, 1958. Hyderabad, 1959.

FRUIT GROWING

CITRUS VIRUS DISEASES; proceedings of a conference on Citrus Virus Diseases, held at the Citrus Experimental Station, Riverside, California, 1957. Riverside (Calif.), 1959.

REPORT OF THE 1st AUSTRALIAN FRUIT RESEARCH CONFERENCE; 1958; convened by C.S.I.R.O. Melb., 1958.

LIVESTOCK

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Obituary

RICHARD PHILIP ROBERTS

1906-1961

Richard Philip Roberts, M.Sc. (Agric.), Officer-in-Charge, Rural Economics and Marketing Section of this Department, died 26th August, aged 55 years, while spending the weekend with relatives and friends at his holiday house at Point Peron. His death was sudden and quite unexpected as he was apparently in good health. His passing has deprived the Department of an outstanding officer of wide experience, sound judgment and great knowledge of his special fields of work.

Mr. Roberts was born in England but came to Western Australia at an early age and lived with his parents on a dairy farm at Waroona. He was educated at Hale School and University of Western Australia where he graduated B.Sc. (Agric.) in 1928 and completed an Honours Course in 1930. This commenced his special studies in rural economics for which in 1934 he was awarded the degree of Master of Science in Agriculture.

From the commencement of his University studies in 1925 Mr. Roberts was a cadet in the Department of Agriculture and became an Agricultural Adviser in 1929 after his graduation. His work was at first mainly in wheatbelt areas and included a period in 1932 on soil surveys in the Gabbin-Bullfinch areas and at Salmon Gums. From 1938 to 1942 he was seconded to the University Institute of Agriculture for rural economics studies. These included power farming, gas producers, the pig industry, dairying, land settlement and organised marketing. In 1945 he associated with Professor G. A. Currie in preparing for the Commonwealth a scheme for the rural training of ex-servicemen.

He was a member of the Royal Commission on Wheat Stabilisation and Marketing in 1945, of a Committee of Enquiry on War Service Land Settlement in Western Australia in 1947, and also served on the Superphosphate Enquiry Committee in 1950. On many occasions he assisted the Director of Agriculture and the Hon. Minister for Agriculture at meetings of Standing Committee on Agriculture and Agricultural Council. He also accompanied many important overseas visitors on tours in Western Australia to give them the benefit of his wide knowledge of the State's agriculture.

Mr. Roberts was for many years Secretary of C.S.I.R.O. State Advisory Committee and State Secretary of the Food and Agriculture Organisation. He resided at St. George's University College since 1943 with post of senior tutor.

A very wide circle of friends and colleagues will long remember the good companionship of Phil Roberts as a sportsman, host, traveller or camper. Visits with him to his holiday homes at Point Peron and Nornalup were a special pleasure for they revealed his interests in nature as well as his wide reading habits, also his culinary skill and taste for good food and wines. He had played cricket, tennis and golf and was still an active squash player.

Tree planting was a special hobby and in the weeks immediately before his death Mr. Roberts saw a large tree planting programme in the Department's South Perth grounds actively in progress. He had been the convenor of the tree planting committee.

Mr. Roberts was unmarried. Two sisters and three nieces survive him.



Palatability of Forage Plants in North-West Sheep Pastures

By R. H. COLLETT, Field Technician, Abydos



Continuous selective grazing has reduced the palatable woollybutt grass (*Eragrostis eriopoda*) to dead butts between clumps of the less palatable soft spinifex (*Triodia pungens*.)

A DECLINE in carrying capacity has occurred in large areas of the Pilbara district of the North-West, due to the decrease in palatable plants and the increase in unpalatable ones. The relative palatability of the various species to sheep is therefore a matter of considerable importance to pastoralists.

Observations at Abydos Research Station near Port Hedland have shown that the sheep's grazing year can be divided into approximately four seasons or stages according to the condition of the native grasses. They are:—(1) The growing stage; (2) the mature stage; (3) the drying-off stage; and (4) the dry stage.

1. The Growing Stage.

At Abydos this stage only lasts for about eight weeks, when the sheep's first preference is for tender young grass shoots and palatable young shrubs.

Most of the native grasses are palatable at this stage but woollybutt grass (*Eragrostis eriopoda*) is usually the most favoured by the sheep.

2. The Mature Stage.

Most grasses become rank and unpalatable once the seed has matured. Generally the palatable shrubs are still the first preference of the sheep, while wind grass (*Aristida arenaria*) is easily the most palatable of the native grasses. In a dry year, however, porcupine spinifex (*Triodia secunda*) may be preferred at this time. Even in a normal year this is the second

most palatable species. Woollybutt grass is the third preference but it shares this position with soft spinifex (*Triodia pungens*) in its first year of growth.

The duration of this period varies with the seasonal conditions and the condition of the paddock.

3. The Drying-off Stage.

The four species named in the previous stage remain the most popular during the drying-off stage, but with porcupine spinifex becoming at least as palatable as wind grass. Soft spinifex may also become very palatable at this stage, depending on seasonal conditions and soil type. A number of other species are also grazed at this time, the main criterion apparently being the presence of green leaves. These are: Weeping grass (*Chrysopogon latifolius*), silver top or curly spinifex (*Plectrachne Shinzii*), hop-a-long (*Neurachne* spp.), *Aristida hygrometrica* (a coarse and stemmy type of wind grass), *Eriachne obtusa*, lemon scented grass (*Cymbopogon* spp.), kangaroo grass (*Themeda* spp.), and native sorghum (*Sorghum timorense*). While these species are listed in the

approximate order of preference, variations may occur with the season and soil type.

4. The Dry Stage.

The three palatable spinifex species provide the bulk of the sheep's diet during this stage, the order of preference depending on the condition of soft spinifex. This varies from very palatable to quite unpalatable. Feed is also provided by various Acacias, such as *A. pyrofilia* (kangi) and *A. translucens* (poverty bush.)

THE PALATABLE SPECIES

Soft or Gummy Spinifex (*Triodia pungens*).

This is the most common of all the palatable native species in the North-West and probably the most important. However, its palatability to sheep varies from plant to plant and sheep rarely graze more than one plant in three. The main reason for this is that sheep prefer young growth, and whereas the young growth of native grasses may only last for two or three months, that of soft spinifex may last for

two or three years. Thus, soft spinifex in its first year of growth is equally as palatable as woollybutt grass in Stage 2 and decreases in palatability as it grows older. The rate at which this decrease in palatability proceeds depends on seasonal conditions, soil type, amount of competition from other plants, the grazing treatment and the topography of the country.

Dying-off plants and plants that have previously been heavily grazed are also favoured by sheep. This may be due to young growth replacing the dead or grazed leaves.

Again, sheep grazing a pure soft spinifex stand during the growing season, differentiate between the plants more by the degree of grazing applied to each plant than by grazing some plants and ignoring others as they normally do. Thus, during the growing season, only the growing tips of the leaves of most plants are grazed, while plants of the type mentioned above are grazed heavily.

The soft spinifex plant usually grows outwards round the edges and dies off from the centre, so that older spinifex plants



A good mixture of soft spinifex (the larger clumps) and perennial grasses, particularly woollybutt grass (*Eragrostis eriopoda*) and "hop-a-long" (*Neurachne clementii*)

are sometimes grazed on the edges—which are younger than the remainder of the plant. However, some plants appear to become inactive and cease either to spread outwards or die off from the centre. Such plants are invariably unpalatable. They were observed at Abydos by mapping a particular area at regular intervals for three years. In spite of heavy stocking of up to one sheep to two acres, these were never grazed. Such plants are probably quite common in old stands of soft spinifex.

The most palatable of all soft spinifex plants are those that have a wilting appearance, and are brown in colour, with a green tinge. They are usually found on the heavier soils in a dry time, their wilting appearance presumably being due to lack of soil moisture. These plants remain palatable only as long as they have gum on the leaves. If this gum is removed due to natural conditions in the paddock, or artificially with acetone, they rapidly dry off and become quite unpalatable.

In a very dry time, particularly if there has been only light summer rain, fairly dense populations of soft spinifex may dry-off completely (due to excessive competition for soil moisture), and become unpalatable. On the other hand, isolated plants which do not have to compete with other plants for the limited supply of soil moisture may have the wilting, brown appearance described above, and be heavily grazed.

Since sheep select young growth (which is usually very gummy), and the brown wilting leaves which are also covered with gum, but will not graze the dry spinifex from which the gum has been removed, it appears that the presence of gum does *not* deter sheep from grazing soft spinifex, but its absence does.

Porcupine Spinifex (*Triodia secunda*).

There may be several species which are called porcupine spinifex, but *Triodia secunda* is the only palatable one. It can be recognised by the fact that the leaves break very easily and are extremely soft and succulent. It normally grows on well drained slopes of fairly heavy soil, when it is the most palatable of all the spinifex species. It is also the one most likely to

remain palatable through a prolonged drought. However, on creek banks and other damp areas it appears to be unpalatable.

Curly Spinifex (*Plechtrachne Shinzii*).

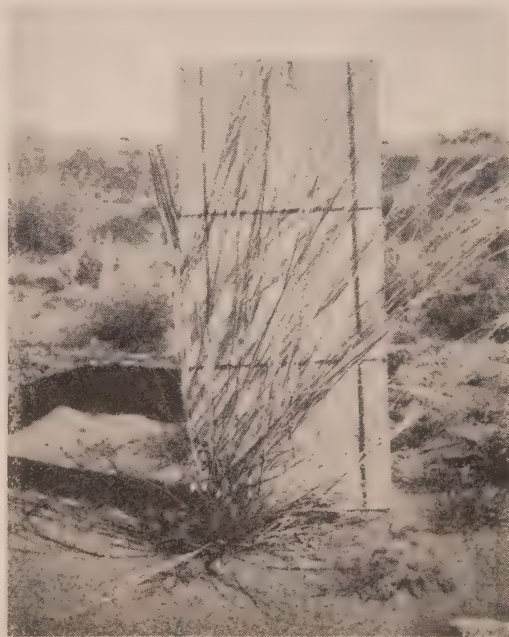
This species will grow on the same types of soil as soft spinifex or even buck spinifex (*Triodia lanigera*). It is not as palatable as soft spinifex at its best, but because the palatability of that species varies so much, *Plechtrachne Shinzii* is often preferred to it.

Wind Grass (*Aristida arenaria*).

The soft fine leaves of this grass make it the most palatable of all the native grasses when mature. Moreover, the mature leaves green up after rain and it continually produces fresh flowering heads when the soil is moist.

Woollybutt Grass (*Eragrostis eriopoda*).

Like wind grass, woollybutt produces fresh flowering heads when the soil is moist, but the mature leaves do not green up after rain. In the mature stage it is



Perennial weeping grass (*Chrysopogon latifolius*), a palatable species

approximately as palatable as soft spinifex in its first year. It is more subject to damage by uprooting in the seedling stage than most grasses.

Weeping Grass (*Chrysopogon latifolius*).

The mature leaves of this grass are generally unpalatable until the drying-off stage. However, the germinating seeds and heavily grazed root butts produce long tender shoots that are very palatable to sheep. These are usually grazed very heavily, thereby preventing the production of seed heads. Sheep will also graze the tips of weeping grass leaves during the growing stage.

Other Grasses.

The remaining grasses named in Stage 3 (the drying-off stage), may be of increased importance if the above species are not available or soft spinifex is in a relatively unpalatable condition. The most palatable of these are hop-a-long (*Neurachne Clementii*), *Aristida hygrometrica*, and *Eriachne obtusa*. Hop-a-long is very susceptible to a virus disease which prevents the production of flowering stems.

SUMMARY

Sheep usually prefer shrubs and the tender young shoots of grasses as long as they are available.

Most of the palatable species may be grazed during the growing stage which, in this district, only lasts for about two months.

For the remaining ten months of the year, wind grass and woollybutt grass are the most palatable of the native grasses; porcupine spinifex, under suitable conditions, is the most palatable of the spinifex species, and soft spinifex in its first year of growth is equally as palatable as woollybutt grass.

Soft spinifex varies so much in palatability that *Plechtrachne Shinzii* may often be preferred to it.

Soft spinifex is not grazed by sheep if the leaves have dried off due to the absence of gum, but brown, wilting leaves—usually found on the heavier soils—are very palatable as long as they are covered with gum.

Young growth of soft spinifex is preferred to old growth—which may be completely unpalatable.

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DRUGS FOR WORM CONTROL

I.—SHEEP DRENCHING TRIALS WITH MK-360

By M. R. GARDINER, B.S., V.M.D., and J. CRAIG, M.R.C.V.S.

DRENCHING sheep with drugs designed to eliminate parasites has become an established practice in the higher rainfall districts of Western Australia. It has been tested in many trials, and there is little doubt that drenching sheep clinically affected with worms—the so-called “tactical” drench—is valuable and necessary. However, there is usually less general acceptance of the value of “strategic” drenching—the prevention of clinical parasitism by giving the drug at certain specific times, pre-determined by a knowledge of the numerical rise and fall of the various parasites within the animal body.

So many factors can enter into the matter of sheep parasitism that it is impossible to answer the problem in terms of a simple solution which could be recommended in all circumstances. What might be a useful procedure for parasite control during one season in one district might not work at all at a different time or in a different place.

Failure to take into account all the modifying circumstances on a property has been responsible for varying and often dogmatic statements on the best way to tackle sheep parasitism. Use of the wrong anthelmintic, or the right anthelmintic at the wrong time, may further complicate the issue.

PARASITISM IN SHEEP

A number of important points must be considered in any appraisal of internal parasitism in sheep. These are:

- (1) The various worm species known to exist in a district and the seasonal trends of each.

This information can only be accumulated by continual surveys year by year.

- (2) Climatic factors affecting development and survival of the free living larval stages on the pasture.

Each species has different optimal requirements for its free living stages.

- (3) The intensity of stocking.

In general, the greater the stocking rate the greater the average worm infestation in the flock.

- (4) The nutritional status of the flock.

Well-fed sheep tend to show less clinical evidence of parasites than poorly fed sheep. They are also better able to withstand the stress of parasitism. However, at least two species, *Haemonchus contortus* (barber's pole worm) and *Chabertia ovina* (the large mouthed bowel worm), can kill sheep on the very best feed, whilst *Nematodirus* species (the thin necked intestinal worm), against which little or no immunity develops in lambs, can be quickly fatal regardless of pasture conditions. Some of the small stomach and intestinal larval forms can so damage the digestive tract, if present in large numbers, that no feeding can compensate for the parasitism. Heavy infestations of *Trichostrongylus* species can depress appetite for periods of up to 12 months.

- (5) Resistance to worms.

This is one of the more important aspects of the problem. Immunity appears to depend mainly on the degree of the sheep's previous experience with parasites. If the animal comes into contact with a few worms of each species, it will inevitably develop a certain amount of resistance against the same species.

This is, of course, merely nature's way of controlling parasitism, ensuring that both the host and the worms will co-exist comfortably without undue hazard to either. Undoubtedly, if sheep were grazed under entirely natural conditions such a biological balance between host and parasite would become established. However,

man has interfered with this balance by limiting the grazing of the sheep within paddocks at intensive stocking rates and on improved pastures. The age-old basis of mutual tolerance in this host-parasite relationship has been so modified that natural immunity as a sole restraint to worm infestation has been defeated, and it is only under pastoral conditions that this is still the most important factor in parasite control.

With intensification of agriculture the balance tends to shift in favour of the worm.

(6) Rotational Grazing Practices.

Theoretically, this method of parasite control offers many advantages to the grazier, and yet a few formidable pitfalls can exist for the unwary. It is, for example, quite possible for a farmer to rotate his sheep right into an overwhelming population of parasitic larvae at exactly the right infective stage for maximum infestation. Short rotations must be avoided and paddocks should be spelled for periods of at least one month.

ANTHELMINTICS

There has been a steadily increasing effort in recent years to discover better worm drenches (or anthelmintics), and this has resulted in a steady flow of new drugs on to the market. It is the purpose of this and future papers to examine the characteristics of these, and to report on our experiences with them in Western Australia.

The basic attributes of a useful anthelmintic are:

(a) It should have reasonable efficiency in removing parasites.

The more species against which the drug acts, the more useful it is.

(b) It is more valuable if it is effective against the immature stages of worms as well as the adults.

One of the more serious defects of many existing drugs is that they do not significantly affect immature parasitic stages. These rapidly mature and if present in large numbers, take the place of the expelled worms. The result is a continuing clinical unthriftiness in the flock.

The only way of dealing with this problem is by a series of properly timed drenches. Drawbacks to such a practice are our lack of knowledge of the extent of immature parasitism in any flock and the need for repeated handling of the sheep.

(c) The drug must have low toxicity to stock.

There are several effective drugs for removing worms, but these may also be harmful to the sheep. Even the best of currently available anthelmintics may temporarily set back the flock; this may be especially so should the parasitism be light and strategic drenching be attempted without full consideration of all modifying factors.

(d) The drug should be free of undesirable side effects.

Such side effects include wool staining and objectionable odours. In the latter instance, for example, an unpleasant taste may decrease, or even stop, rumination.

(e) The drug must be easy to mix and to administer, and it must not be unduly expensive.

TRIALS WITH MK-360

ABOUT a year ago, small supplies of the new drug MK-360 became available for experimental use. This compound, whose chemical formula is 2-(4'-thiazolyl)-benzimidazole, is also known as "Thiabendazole."

Two methods were used to assess the efficiency of this anthelmintic. Critical trials were conducted in the laboratory, and field studies were carried out to test

the value of the drug under practical conditions.

This paper, based on the data obtained in these trials, reports on the potential value of MK-360 in Western Australia.

A.—CRITICAL TRIALS

1.—Drenching of parasitised weaners:

On February 3, 1961, 12 very heavily parasitised weaners were obtained from the C.S.I.R.O. "Glen Lossie" Field Station, Kojonup. Two of these animals were affected with pneumonia and obviously had greater parasite burdens than the others. These two and four others chosen at random, were selected for drenching, while the other six were kept as undrenched controls.

Pre-drenching worm egg counts and larval differentiations* were done on all 12 sheep.

The results are shown in Table 1 (see Appendix) where it can be seen that there were no *H. contortus* in any sheep, that high proportions of both *Trichostrongylus* species and *C. ovina* were present and that there were light infestations with *Ostertagia* species.

The six selected sheep were then drenched with one fluid ounce of MK-360. The two sick sheep died during the next two days, but as these were extremely sick when the trial began, we have no reason to believe that the drug itself was responsible for the deaths. (The animals had travelled by truck from the station and had been kept overnight before drenching. It is likely that besides marked parasitism the group had suffered from the transportation.)

Sheep from both groups were killed three, five and seven days after drenching. The contents of the abomasum, small intestine and colon were examined for total worm burdens and species differentiation. The abomasum, and the first 20 ft. of the small intestinal mucosa were digested in accordance with standard procedures, and worm numbers and species determined.

The results are presented in Table I. It will be seen that all the undrenched weaners had heavy parasitic burdens, while drenched weaners were almost parasite-free.

* Larval differentiations are done by culturing sheep faeces at 24°C and identifying the various species of larvae that emerge from the eggs after 7 days. The percentage of each species is recorded.

The point system followed here to assess degree of parasitism is based on the following:—

<i>Ostertagia</i> spp. (Brown Stomach Worm)	3,000 worms = 1
<i>H. contortus</i> (Barber's Pole Worm)	500 worms = 1
<i>T. axei</i> (Stomach Hairworm)	4,000 worms = 1
<i>Trichostrongylus</i> spp. (Black Scour Worm)	4,000 worms = 1
<i>Nematodirus</i> spp. (Thin Necked Bowel Worm)	3,000 worms = 1
<i>Chabertia ovina</i> (Large Mouthed Bowel Worm)	100 worms = 1
Immature Worms (all species)	4,000 worms = 1

This table shows that 3,000 *Ostertagia* will cause roughly the same amount of damage to a sheep as 500 *H. contortus*, 4,000 *T. axei*, and so on. It also emphasises the seriousness with which we regard infestations by the large mouthed bowel worm.

The degree of parasitism in the undrenched weaners thus ranged from four to 11. Any degree in excess of two in a young weaner is considered significant, and in these weaners (aged eight to nine months) such a level is judged harmful. Degrees of parasitism which we consider to be in the lethal range were found in three of the group—

No. 3031 (11) No. 2821 (10) and No. 3013 (10).

The average counts for the six undrenched sheep and the four surviving drenched sheep for the various worm species, and the calculated anthelmintic efficiencies were:—

	Control	Drenched	Efficiency	
<i>Ostertagia</i> spp.	3,600	25	99	} Abomasal contents
<i>T. axei</i>	4,860	25	99	
Immature	1,680	60	96.5	
<i>Ostertagia</i> spp.	740	12	98.5	} Abomasal wall and mucosa
<i>T. axei</i>	2,560	100	96	
Immature	1,810	90	94.5	
<i>Trichostrongylus</i> spp.	4,880	12	99	} Small intestinal contents
<i>Nematodirus</i> spp.	730	0	100	
Immature	3,270	0	100	
<i>Trichostrongylus</i> spp.	430	125	70	} Small intestinal wall and mucosa
<i>Nematodirus</i> spp.	0	12	0	
Immature	280	12	96	
<i>C. ovina</i>	224	0	100	

Most parasitic species were represented here; an exception was *H. contortus*. Of particular interest were the numerous immature stages and the large numbers of *C. ovina* in the control sheep, and the high efficiency of the anthelmintic against these parasitic forms. The drug appeared to be highly effective against all species in all situations except for *Trichostrongylus* spp. in the intestinal wall and mucosa, for which a figure of 70 per cent. efficiency was calculated. Too few *Nematodirus* spp. were present for evaluation.

Various degrees of infestation by the lung worm (*Dictyocaulus filaria*) were found in all these sheep. No estimate was made of the number contained in each lung but three was the lowest number counted, and in some cases, 50 or more were seen. There was no visible effect of the drug on these parasites.

2.—Drenching of parasitised "lupinosis" sheep:

In April, 18 parasitised sheep affected with lupinosis were brought to the Animal Health Laboratory. One of the objectives in the subsequent study was the evaluation of MK-360 and other drugs as worm drenches in sheep affected with lupinosis, as the toxic hazard is especially great in this disease. This toxicity evaluation will be reported later, and only the anthelmintic efficiency discussed here.

The experimental procedure was identical to that described in the first experiment, except that 1½ oz. of MK-360 were given in order to accentuate the drug's toxic potential. Instead of undrenched controls, four sheep received a high (1½ oz.) dose of finely divided phenothiazine.

Results of pre-drenching worm egg counts and larval differentiations, and of the worm counts in the various parts of the digestive tract three days after drenching, are presented in Table 2.

These investigations showed that *H. contortus* was present in both groups and was completely eliminated by both drugs. In this trial MK-360 had no greater efficiency than phenothiazine in removing the stomach hairworms (*Ostertagia* spp. and *T. axei*) but it was far more effective in clearing out the various intestinal species, both those inhabiting the lumen of the bowel and those buried in the wall. Against both the small and large intestinal forms,

MK-360 efficiency was practically 100 per cent. and the same marked activity against immature stages was demonstrated as in the first critical trial.

B.—FIELD EXPERIMENT

Early in October, 1960, 80 crossbred wether weaners at Muresk Agricultural College, Northam, were randomised into five groups of 16 sheep each, the sheep being individually ear-tagged and all groups paddocked together.

During most of the summer the weaners were maintained in a wheat stubble paddock. No supplementary feeding was carried out before March, when they were fed oaten grain at the rate of half a pound a head a day. The experimental treatments were:

Group Drenching Schedule.

1. Control—Not drenched.
2. Phenothiazine (2 drenches)—1 oz. January 18 and February 28.
3. Phenothiazine (3 drenches)—1 oz. November 23, January 18, and February 28.
4. MK-360 (2 drenches)—1 oz. January 18 and February 28.
5. MK-360 (3 drenches)—1 oz. November 23, January 18, and February 28.

Droppings from all sheep were collected for worm egg counts and larval differentiations at monthly intervals, starting on October 26 and continuing until March, 1961. All sheep were weighed regularly during the experiment, so that the effect of each drenching programme could be measured by both parasitic burdens and sheep live weights.

The accumulated data were statistically analysed. Results of worm egg counts and larval differentiations are shown in Table 3 and the monthly average weights of each group during the trial in Table 4.

RESULTS AND DISCUSSION

On December 22, one month after groups 3 and 5 had been drenched with phenothiazine and MK-360 respectively, the worm egg counts of the MK-360 sheep had been reduced essentially to zero, and those

of the phenothiazine group also showed a significant reduction.

The three undrenched groups at this time continued to show a level of between 300-400 eggs per gram.

The phenothiazine treatment had materially reduced the light infestation of *H. contortus* (barber's pole worm) which existed in all groups throughout October and November but had no obvious effects on the *Ostertagia* (brown stomach worm) or *Trichostrongyle* (black scour worm) populations.

The MK-360 treatment eliminated the *H. contortus* infestation and very significantly reduced the infestations by both *Ostertagia* and *Trichostrongylus*.

The light infestations of *C. ovina* (large mouthed bowel worm) carried in all sheep during October and November were lost by natural means, regardless of treatment, by late December.

There were no significant weight differences between any of the groups in late December, indicating that although parasitism had been effectively reduced in the MK-360 treated group, this had not significantly affected weight gains.

On January 18, at the time of the second drench of groups 3 and 5, and the first drench of groups 2 and 4 with phenothiazine and MK-360 respectively, the sheep drenched in late November still showed a significant depression of worm egg counts. This is interesting because it clearly shows that even though the treated animals were grazing with untreated ones throughout December and January, there was no pick-up of parasites. This was presumably due to pasture conditions being unfavourable for the development or survival of free-living larval worm stages.

On February 15, four weeks after groups 2 and 4 had received their first drenches, and groups 3 and 5 their second drenches of phenothiazine and MK-360 respectively, worm egg counts rose in the (untreated) control sheep, with a persistence of previous infestation levels of *H. contortus*, *Ostertagia* spp. and *Trichostrongyles* spp. and, interestingly, a second wave of infestation by *C. ovina*.

[During January, 131 points of rain fell at Muresk (Table 6), and this may have provided conditions suitable for the development of free living larval worm stages. However, in an extensive trial at

Kojonup in 1959-60 (Parnell), rains at the end of December and beginning of January appeared to have no effect on worm burdens, so that the January rainfall at Muresk may not in fact have affected the worm burdens in untreated sheep.]

The worm egg counts on February 15, indicated significantly reduced worm burdens in all four treated groups. The reduction was much greater in sheep treated with MK-360 than in those treated with phenothiazine.

At this time, it was apparent that treatment with phenothiazine had done little to alter the relative populations of the different parasitic species except to depress *C. ovina*. It seemed probable that the decline in worm egg counts in the two phenothiazine groups was due to its effect on this species.

On the other hand, MK-360 had a profound effect on *H. contortus* and *C. ovina* and a significantly depressing effect on the *Ostertagia* and *Trichostrongyle* species.

By mid-March, worm egg counts on the control sheep reached the highest level of the trial.

It is suggested that this rise resulted either from maturation of *C. ovina* larval stages within the animals during February and March, or from the more favourable conditions following the unseasonal January rains which allowed a build-up of free living *C. ovina* larval forms. However, Threlkold (1947) found that *C. ovina* has a much longer prepatent period (the interval between the ingestion of infective larvae from the pasture and the start of egg laying by the adult females) than other sheep parasites, this being seven to eight weeks, compared with about three weeks for most other species. Therefore, it is likely that the marked increases in the numbers of *C. ovina* (in groups 1, 2, 3 and 4) in February and March was due to larval uptake in December or even earlier. This is a further indication that the MK-360 drench on November 27, with its potent effect on immature worm stages, was responsible for the absence of this parasite in Group 5 in February and March.

Once again worm egg counts were significantly reduced in all treated groups, with the MK-360 groups having significantly lower counts than the phenothiazine groups.

The triple drenching with MK-360 virtually eliminated both *H. contortus* and *C. ovina*, but delaying the first drench of this drug until late January allowed some development of these species. There was some evidence that this treatment difference on *C. ovina* also existed between phenothiazine-dosed groups.

This very interesting result indicated that some phase of the life cycle of this species had been interfered with by November treatment, and that, even though the January treatment very effectively and materially reduced *C. ovina* infestations, using either phenothiazine or MK-360, the drenches given two months earlier were necessary to prevent subsequent development of this parasite.

The January and February drenches, in spite of their effects on parasitic burdens as outlined above, had no significant effect on body weights from January to March. All groups showed slight losses.

However, between the March and April weighings all treated groups lost less weight than the untreated control group. Statistical analysis showed that these differences were significant at the 1 per cent. level. Similar analyses of the weight gains from November to April showed that all treatments significantly increased weights and that the MK-360 groups gained significantly more weight than the phenothiazine groups.

These results prove that drenching of sheep, even at these low levels of parasitic infestations, were instrumental in improving weight gains. The net gains for the phenothiazine treated groups were $1\frac{1}{2}$ to 2 lb. per sheep more than the controls, while the MK-360 groups gained an average of $6\frac{1}{2}$ to $7\frac{1}{2}$ lb. more.

On body weight results, there were no differences between two and three drenches either with phenothiazine or MK-360. Furthermore, there were no obvious effects from drenching in November apart from the interference to the life cycle of *C. ovina*, discussed above. However, during the summer-autumn nutritional decline and following the early April opening rains, sheep drenched in January-February had an advantage over those not drenched. This advantage was far greater in the MK-360 drenched sheep than in the phenothiazine drenched sheep.

Our results, although suggesting that the November drench was probably unnecessary, do not clearly indicate whether two drenches in mid-summer are essential for the improvements noted or whether one drench in either January or February would be sufficient.

In districts where *C. ovina* can have serious mid-summer consequences, a November drench may prove valuable. This point will be investigated in future experiments.

One week after the January and February drenches, one sheep from each group was brought to the laboratory for complete worm counts as described under Critical Trials. This gave a check on the effectiveness of each treatment, compared with a control sheep. Results are shown in Table 5.

It can be seen from the table that phenothiazine had little effect on the removal of the Stomach and Intestinal Hairworms but that MK-360 eliminated most worms of all species. These results were comparable with those obtained in the Critical Trials.

ACKNOWLEDGMENTS

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Messrs. Merck, Sharp and Dohme, Rahway, N.J., U.S.A. supplied the MK-360 for the conduct of these studies. The "Glen Lossie" Field Station, and Muresk Agricultural College donated most of the experimental sheep. To all of these we extend our thanks.

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APPENDIX

Detailed Tabulation of Experimental Results.

TABLE 1

MK-360 DRENCHING TRIAL (WITH HEAVILY PARASITISED WEANERS)

Sheep No.	Treatment	Pre-drenching Egg Counts	Pre-drenching Larval Differentiation (per cent.)				Abomasal Parasites				Intestinal Parasites				Degree Parasitism	Days after drench Sheep killed							
			Haemonchus	Trichostrongyles	Ostertagia	Chabertia	Abomasal Contents				Intestinal Contents												
							Haemonchus	Ostertagia	Trich. axel.	Immature	Trichs.	Nematodirus	Chabertia	Trichs.			Nematodirus	Immature					
3031	Undrenched	Eggs per gram. 8900 (50N)*	0	70	2	28	0	7300	3800	1300	0	4000	9600	1750	8850	450	2900	0	1450	0	450	11	
2355	do.	900 (50N)	0	86	4	10	0	1600	3300	700	0	400	1300	1600	6900	1750	2100	180	200	0	200	7	
2821	do.	1700 (50N)	0	53	7	40	0	7700	8950	3650	0	50	1300	600	2250	800	1350	325	150	0	100	10	
3101	do.	1450 (150N)	0	37	6	57	0	1750	6500	750	0	0	600	1150	950	1150	850	88	350	0	50	4	
3010	do.	2800 (50N)	0	10	3	87	0	2250	2150	900	0	0	1700	4700	550	250	400	500	0	150	8		
3013	do.	3150 (50N)	0	86	6	8	0	900	4450	2800	0	0	850	1050	9800	0	1200	250	450	0	750	10	
3032	Drenched with MK-360	3250	0	72	4	24	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	3
3047	do.	850	0	55	6	39	0	50	0	50	0	0	50	100	50	0	0	0	100	0	0	0	3
3017	do.	2300 (50N)	0	72	7	71	0	50	100	0	0	0	350	250	0	0	0	0	400	50	0	0	5
2957	do.	4150 (50N)	0	25	2	73	0	0	0	200	0	0	0	0	0	0	0	0	0	0	50	0	4
2991	do.	8700	0	44	8	48	0	3500	2400	1000	...	...	Died within 24 hours of drench.	Died within 24 hours of drench.	0	0	0	0	...	...	...	...	...
2631	do.	Could not do due to severe scour.	0	...	...	...	0	0	0	0	0	...	Died within 24 hours of drench.	Died within 24 hours of drench.	...	...	...	...	...	...	...	...	...

* Nematodirus eggs shown in brackets.

TABLE 2
MK-360 DRENCHING TRIAL (WITH LUPINOSIS SHEEP)

Sheep No.	Pre-drenching Egg Counts	Pre-drenching Larval Differentiation (per cent.)				Drench	Abomasal Contents				Abomasal Wall			Intestinal Contents				Intestinal Wall		
		H. contortus	Ostertagia	Trichs.	Chabertia		H. contortus	Ostertagia	T. axei.	Immature	H. contortus	Ostertagia	T. axei.	Immature	Trichs.	Nematodirus	Immature	Chabertia	Trichs.	Nematodirus	Immature
6	Eggs per gram.	0	20	64	16	Pheno	0	50	0	100	0	0	0	800	0	550	0	0	150	0
4	300	0	13	82	5	do.	0	100	0	0	0	0	0	1450	150	2250	0	0	400	850
7	550	4	10	79	7	do.	0	300	200	100	0	0	0	0	100	50	0	0	0	0
16	800	11	1	69	19	do.	0	100	200	0	0	0	0	4700	1000	0	80	50	0	50
Average...	950	4	11	73	12	...	0	140	100	50	0	0	0	1740	350	710	20	150	0	225
5	3100	0	2	43	55	MK 360	0	0	100	0	0	0	0	0	0	0	0	0	0	0
12	250	0	11	75	14	do.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1400	2	7	55	36	do.	0	1000	200	0	0	0	0	0	0	50	0	0	0	0
1	400	...	...	...	...	do.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	4050	16	4	80	0	do.	0	50	0	0	0	0	0	50	0	0	0	0	0	0
18	400	12	5	78	5	do.	0	200	0	0	0	0	0	0	0	0	0	0	0	0
15	400	10	8	54	28	do.	0	150	0	0	0	0	0	0	0	0	1	0	0	0
Average ..	1400	7	6	64	23	...	0	200	43	0	0	0	0	7	0	0	0	0	0	0

TABLE 3
MURESK FIELD TRIAL
ACCUMULATED LARVAL COUNTS

Group	Monthly Average Egg Counts e.p.g.						H. Contortus			Ostertagia				Trichostrongyles						Chabertia				
	Oct. 26	Nov. 23	Dec. 21	Jan. 19	Feb. 16	Mar. 16	Oct. 26	Nov. 23	Dec. 21	Jan. 19	Feb. 16	Mar. 16	Oct. 26	Nov. 23	Dec. 21	Jan. 19	Feb. 16	Mar. 16	Oct. 26	Nov. 23	Dec. 21	Jan. 19	Feb. 16	Mar. 16
1. Control	284	294	337	203	323	500	260	161	116	168	133	140	72	72	56	51	118	101	897	500	1311	1381	847	644
2. Pheno.	406	281	307	316†	190†	182	464	285	403	153†	245†	57	60	111	39	51†	107†	131	1108	1068	167	1296†	884†	1087
3. Pheno.	428	253†	175	137†	193†	115	331	307†	197	84†	127†	81	57	58†	40	35†	194†	69	892	871†	1863	1268†	851†	749
4. MK-360	268	260	290	165†	44†	64	253	321	174	225†	9†	30	58	37†	21	21†	67†	75	1080	1050†	279	489†	425†	825
5. MK-360	378	306†	10	22†	13†	82	478	245†	0	16†	8†	0	65	37†	21	21†	67†	75	903	1050†	279	489†	425†	825

† = Drenched.

TABLE 4
MURESK FIELD TRIAL
AVERAGE WEIGHTS OF EACH GROUP AT EACH INTERVAL (POUNDS)

Group	Oct. 26	Nov. 27	Dec. 23	Weight Gain, Nov. 27-Dec. 23	Jan. 19	Mar. 26	Apr. 17	Weight Loss, Mar. 26-Apr. 17	Total Weight Gain, Nov. 17-Apr. 17
1. Control	78.5	82.5	88	lb. +5.5	83	87	80	lb. -8	+1.5
2. Pheno.	77	78	85	+12	85	84	80	-4	+3.0*
3. Pheno.	77.5	78	85	+8	83	83	76	-4	+3.1*
4. MK-360	77	79	87	+8	90	89	85	-4*	+8*
5. MK-360	79	84	93	+9	95	91	88	-3*	+9.1

* Different from Control Group at 1% level.

† Different from Pheno. Groups at 5% level.

TABLE 5

MURESK FIELD TRIAL
INDIVIDUAL SHEEP WORM COUNTS, JANUARY AND FEBRUARY
ONE WEEK POST DRENCHING

Month	Treatment	Abomasal Contents					Abomasal Mucosa and Wall				Intestinal Contents				Intestinal Mucosa and Wall		
		GROUP	<i>H. contortus</i>	<i>Ostertagia</i> spp.	<i>T. axei</i>	Immature	<i>H. contortus</i>	<i>Ostertagia</i>	<i>T. axei</i>	Immature	<i>Trich. spp.</i>	<i>Nematodirus</i> spp.	Immature	<i>Chabertia</i>	<i>Trich. spp.</i>	<i>Nematodirus</i> spp.	Immature
January	None	1	0	150	150	100	0	300	350	100	1300	300	5200	0	200	0	600
	Pheno. twice (a)	2	0	350	150	0	0	350	600	750	1250	250	1850	0	0	0	50
	Pheno. thrice (b)	3	700	650	1350	3300	0	50	600	50	3300	700	11100	0	0	0	500
	MK-360 twice (a)	4	0	0	50	50	0	0	0	150	0	0	100	0	0	0	0
	MK-360 thrice (b)	5	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
February	None	1	0	500	100	100	0	0	300	100	500	0	100	0	0	0	0
	Pheno. twice (a)	2	0	400	150	250	0	0	400	400	400	450	800	60	0	0	0
	Pheno. thrice (b)	3	0	350	100	150	0	0	350	100	550	600	600	0	0	0	0
	MK-360 twice (a)	4	0	0	50	0	0	0	50	100	0	0	0	0	0	0	0
	MK-360 thrice (b)	5	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0

(a) Drenched January 18 and February 28. (b) Drenched November 23, January 18, and February 28.

TABLE 6

RAINFALL, MURESK, 1960-61

Month	Rainfall (Points)
June, 1960	241
July, 1960	720
August, 1960	78
September, 1960	179
October, 1960	16
November, 1960	2
December, 1960	0
January, 1961	131
February, 1961	37
March, 1961	47
April, 1961	273
May, 1961	69

SUMMARY

The new anthelmintic, MK-360 (2-(4-thiazolyl)-benzimidazole) was studied critically and in the field, in Western Australia.

In critical trials it was shown that MK-360 was almost completely effective in eliminating *H. contortus* (Barber's Pole Worm), *C. ovina* (Large Mouthed Bowel Worm) and the immature stages of all species, and highly effective against adults of the small abomasal and intestinal worm species (*Ostertagia* and *Trichostrongyles*).

Field trials in the Northam district showed that drenching sheep in January and February improved weight gains from November to April by 1½ lb. for phenothiazine by 6½ lb. for MK-360, compared with undrenched sheep.

A late November drench, in addition to the summer drenches, gave further slightly increased weight gains, and may have been important in preventing mid-summer infestations by *C. ovina*, which appears to be the parasitic species chiefly responsible for weight losses in weaner sheep during the summer months in this district.

PLANT DISEASES

ROOT LESION EELWORM (*Pratylenchus penetrans*) IN VEGETABLES

The root lesion eelworm is much less widely known than the root knot eelworm, but can damage crops and reduce yields. Preliminary tests indicate that soil fumigation may give good control.

By OLGA M. GOSS, B.Sc. Hons., Plant Pathologist

ROOT lesion nematodes (*Pratylenchus penetrans*) have been found in many market gardens in the Balcatta-Osborne Park and Spearwood areas, associated with such crops as carrots, parsnips, swedes, lettuce, celery and rhubarb.

These worms are often recovered in considerable numbers from sections of crops showing stunted growth or where poor quality root crops are being harvested.

Damage caused by this eelworm does not result in galling, as occurs with the root knot eelworm. Rather, *Pratylenchus* causes root injuries which facilitate the entry of secondary rotting organisms. As a result, the feeder or absorbing root system is seriously depleted and the large bulbous roots in contact with the soil are often extensively rotted or malformed.

In carrots and parsnips, a marked forking has been observed where counts of *Pratylenchus* have been high.

For a number of years, a severe canker-ing and russetting of swedes was noted in the Mandogalup area, the cause of which was unknown (see Figs. 1 and 2).



Fig. 1—Swede turnip showing severe cankering due to root lesion-eelworm attack followed by secondary rotting



Fig 2—Swede turnip showing russetting of root surface due to root lesion eelworm attack. Note also small size of the root



Fig. 3—Swede turnip harvested from fumigated plot. Note absence of russetting and cankering and good size. Compare figs. 1 and 2 which were harvested at the same time from control plots

Previous investigations had shown that this condition could not be attributed to nutritional defects or fungal disease attack. Recently root lesion eelworms were found in high numbers both in the soil from which cankered swedes were being harvested, and in the cankers themselves.

An exploratory pre-planting fumigation trial with DD or EDB was therefore suggested to the grower, who carried out small scale tests with both materials at rates varying from 15 to 30 gallons per acre.

The results obtained are of considerable interest. Soil fumigation with each material greatly reduced canker development, particularly at the higher rates of 20 to 30 gallons an acre (see Fig. 3). Reduction in disease incidence was also correlated with reduction in *Pratylenchus* numbers. Each pound of soil fumigated at 25 and 30 gallons an acre contained from 0 to 20 eelworms, whereas control plots gave 350 to 400 a pound of soil.

An experiment to assess the importance of this eelworm in swedes is planned for next season.



AERIAL SPRAYING TRIALS

Recent trials have shown that aerial application of "extra low" volumes of hormone-like herbicides, with oil or water solvents, does not damage cereals if spraying is done at the right stage of growth.

by

G. R. W. MEADLY, M.Sc., Officer-in-charge,
Weeds and Seeds Branch.

SPRAYING cereal crops for weed control is now standard farming practice in Western Australia. Almost 500,000 acres of cereal crops, mainly wheat, are sprayed each year, and approximately three-quarters of this area is treated by aircraft.

The two main weeds concerned are wild radish (*Raphanus raphanistrum*) and wild turnip (*Brassica tournefortii*), with mustards (*Sisymbrium* spp.) and saffron thistle (*Carthamus lanatus*) involved to a lesser extent.

Although the 2,4-D (or hormone-like) herbicides used for spraying these weeds are probably the most selective that have been developed, crop plants are by no means immune to them. Species such as lupins, tomatoes and vines are highly susceptible and extreme care must be taken when using 2,4-D, even some distance away. Grasses, including the cereals, are relatively resistant but can be damaged if reasonable care is not exercised.

World-wide research has been undertaken to assess the tolerance of cereals to various formulations of 2,4-D, and in view of the importance of these chemicals to West Australian agriculture, a series of experiments has also been carried out in this State. The investigations have incorporated a number of variables including the type of cereal (wheat, oats or barley), variety, growth stage, type and rate of herbicide and volume of application.

Stage of Growth:

As a result of this work it has been known for some time that the effect of 2,4-D on cereals depends largely on the growth stage at which the chemical is

applied. There is also some variation according to the type of cereal and the formulation used.

There are two periods of greater risk. The first is at the seedling stage and continues until the plants are stooling freely, while the second is at the "boot" stage when the head becomes apparent as a swelling in the leaf sheath.

The hazard remains during the flowering period but again decreases when the grain has reached the milk or soft dough stage.

This means that spraying should be carried out after the cereal is stooling freely but before the head has obviously commenced to form.

Toxicity on Cereals:

The nature of the effects on cereals usually varies according to the time they are caused.

Treatment during the early danger period can result in a number of malformations and growth disturbances. Wheat may produce club shaped ears with an irregular arrangement of spikelets. The glumes may become fused and the number of spikelets reduced, producing interrupted heads. Both leaves and heads often become twisted in a grotesque manner.

Late spraying is more inclined to reduce grain setting than cause conspicuous abnormalities. Oats is more likely to be



This wheat crop, containing wild radish, is at the growth stage most suitable for spraying

affected than wheat, with barley intermediate.

The grading of the most frequently used chemicals in decreasing order of risk is:— 2,4-D ester, 2,4-D amine, M.C.P.A. But this grading must be interpreted in terms of toxicity to weeds, which follows roughly the same pattern at comparable rate levels, 2,4-D ester being the most effective.

AERIAL APPLICATION

Aerial application of herbicides has been developed to a greater extent in Western Australia than any other State. About 350,000 acres are sprayed by aircraft each year.

Low Volume Technique:

When the method was first used the accepted volume of application was $1\frac{1}{2}$ to two gallons an acre. Tiger Moths, with a payload of about 300 lb., could spray a maximum of 20 acres with each fill.

Experimental work carried out by the aerial operators in co-operation with the Department of Agriculture has since resulted in good control of wild radish and wild turnip with half gallon of solution an

acre, and some commercial spraying is being done with one quart an acre. With the one quart rate, oil, rather than water, has been used as the carrier.

This "extra-low" volume technique means that, at the half gallon rate, 60 acres can be sprayed with each fill of the tank, and there is a substantial saving in time and cost.

It has been claimed that the half gallon rate and, in particular, the quart of oil an acre, have produced more abnormal heads and a lower yield than conventional rates.

However, several years' field observations have shown that, providing the equipment is well designed and the spraying operations are thorough, weed control with the lower volumes is equal to that obtained with $1\frac{1}{2}$ gallons of spray an acre. There has been no evidence of a greater proportion of abnormalities in the crops due to low volume spraying.

Aerial Spraying Trials:

To avoid the difficulties involved in making experimental spray applications with aircraft a special boom was constructed and fitted to a four-wheel drive vehicle, to simulate aerial spraying.



Malformed heads of wheat, resulting from spraying too early with 2,4-D. The safest stage for spraying cereals is after the plants are stooling freely, but before the "boot" stage

Using this equipment a trial was carried out in 1959 at Wongan Hills Research Station. The following treatments were applied to Gabo, Bencubbin and Insignia Wheat:—

Chemical	Acid equivalent (ounces per acre)	Solvent	Volume (pints per acre)
2,4-D ester	6	Distillate	2
2,4-D ester	12	Distillate	4
2,4-D ester	6	Water	2
2,4-D ester	12	Water	2
2,4-D amine	8	Water	2
2,4-D ester	6	Water	4
2,4-D ester	12	Water	4
2,4-D amine	8	Water	4
2,4-D amine	16	Water	4
2,4-D ester	6	Water	8
2,4-D ester	12	Water	8
2,4-D amine	8	Water	8
2,4-D amine	16	Water	8

but there was no obvious relationship to the volume of either water or distillate, and no significant difference in yields between the various treatments.

For more conclusive results, further trials were carried out at the Wongan Hills Research Station in 1960, in which the spray applications were actually made by aircraft. This was made possible by the ready co-operation of the Aerial Operators Association of Western Australia.

The treatments were:—

Chemical	Acid equivalent (ounces per acre)	Solvent	Volume (pints per acre)
2,4-D ester	6	Distillate	2
2,4-D ester	6	Water	2
2,4-D ester	6	Water	4
2,4-D ester	6	Water	8

Some malformed heads developed, particularly in the higher rates of ester plots,

Plots 10 chains long by two chains wide were randomised in four blocks, and half

of each plot received a double treatment in an attempt to assess any effect of overlapping which might occur under normal aircraft operating conditions. When the spraying was carried out on August 11, the Gabo wheat was at the growth stage regarded as being most tolerant to 2,4-D, being from six to eight inches high and stooling freely. Very few weeds were present.

Conditions were favourable for aerial application, the day being fine with only a slight breeze. The extent of spray drift was constantly checked and the plot markers placed accordingly.

Experimental work with aircraft is far from simple, particularly in relation to spray drift and maintaining direction, as well as a uniform height of spraying. The applications were made by two Tiger Moth aircraft operated by very efficient pilots and careful observations were made to check on the accuracy of the spray applications.

The plots were examined several times during the season and at no stage were abnormalities detected, even on the sections receiving double rates.

Seed heads were well formed and there was no evidence of the discoloration which has occurred with some crops and has been attributed, at times, to "extra low" volume application, particularly with oil solvents.

Yields were estimated by harvesting a strip down the centre of each treatment. These confirmed the visual observations, the average yield being 39 bushels an acre, with no significant differences between treatments.

As the control plots were free of weeds these did not present a complicating factor in assessing the effects of the chemicals on the wheat.

Repeatability under different seasonal conditions is always important with this type of investigation. The results of the 1960 trials, with those of simulated aerial treatment experiment of 1959, indicate that the application of herbicides at "extra low" volumes by means of aircraft is a sound practical method, providing the known necessary precautions are taken.

These same precautions are also essential when using ground equipment, the main consideration being not to spray too early.

ACKNOWLEDGMENTS

These investigations were made possible by the co-operation of the Aerial Operators Association of Western Australia. Thanks are due to that Association, and the pilots who undertook the precision flying required by the experiment.



Aircraft are used extensively for spraying weeds. They operate at 10 to 15 feet above the ground. Skilful flying gave accurate spray application in these trials

SOIL SALINITY IN WESTERN AUSTRALIA

The background to Western Australia's soil salinity problems, and a description of the main types of salt-affected land, by Senior Soil Research Officer, S. T. Smith, B.Sc. (Agric.)

SOIL SALINITY has followed the agricultural development of many Western Australian soils, and has occurred at intervals of from 10 to 30 years after clearing the native vegetation. Most of this problem occurs in the areas of lower rainfall, that is, the 12 to 25 inch rainfall zone.

Within this area about 23 million acres of land have been alienated. Salt affected land within this same area comprises about one million acres, although of this only 200,000 acres has become salt affected as a result of agricultural development.

The remainder is made up of salt lakes and channels which were salt affected before agricultural development.

TYPES OF SALT PROBLEM

In the Western Australian wheatbelt salt encroachment assumes three distinct forms:

1. Valley Water Logging.

In this type of salt land, the most extensive of the three forms, the land is underlain by shallow water tables—usually six

or seven feet from the surface. It is common in broad, flat valleys of low gradient. The underground water varies in salinity from about 1,000 to 4,000 grains per gallon common salt, compared with sea water at about 2,400 grains per gallon.

2. Salt Seepage.

Salt often appears on hill slopes where water seeps out on the surface. These seepages are most common in wetter districts. Seepage water varies from quite fresh up to about 800 grains per gallon of common salt (NaCl). Salt seepages vary from a few square yards to 10 to 15 acres in extent, and while the total area of such salt affected soils in Western Australia is not large, they act as focal points for water erosion.



An area where water seepage on a slope has caused a bare salt area to develop. Consequent erosion is obvious.

3. Dry Land Salt.

In this type, water tables or "free" water are absent. It usually affects only certain soil types, such as the powdery "morrel" soils.

ORIGIN OF SALT

While a certain amount of salt in the soils of Western Australia could be the result of marine submersion it seems most likely that the salt brought in from the sea and deposited by falling rain is the major source. Various workers have measured atmospheric accessions and have shown that salt is deposited in fairly large amounts in the near coastal districts but that the amount decreases as one progresses inland. On the west coast, 100 to 500 lb. of salt an acre may be deposited each year, while 160 miles inland the figure is no more than about 15 lb. of salt an acre, and some of this may be of terrestrial origin.

In areas of sufficient rainfall and suitable topography much of this salt is ultimately washed into the streams and river systems and returns to the ocean. There are, however, many areas of flatter topography in which this cycle is not completed and accumulations take place. One must of course look upon such accumulations as occurring over a very long period.

MECHANISM OF SALT ENCROACHMENT

Salt encroachment in Western Australia is the result of an unfavourable moisture balance in the soil. This moisture balance may be examined under two sets of conditions.

Firstly on heavy textured *virgin* soils

under low rainfall conditions most of the rainfall is utilised where it falls. Consequently there is little or no removal of salts and it is possible for them to go on accumulating *within the soil profile*. Any conditions allowing this salt to subsequently accumulate at the soil surface will give the dry land salt problem to which reference will be made later.

Secondly we can envisage conditions in which there is some removal of cyclic salt by seepage waters even under virgin land. However, should this rate of seepage increase beyond the capacity of the country to discharge it safely into active river systems, accumulation can take place. This increase in seepage occurs as a result of clearing native vegetation and replacing it with plants not capable of utilising the same amount of moisture. This upset in moisture balance, with a resultant increase in water seeping to lower levels without effective discharge into rivers, gives rise to two types of salt encroachment—hillside seepages and valley waterlogging. These principles can be illustrated by examining each type of salt problem.

1. Hillside Seepage: The removal of the deep rooted perennial native plants so reduces the amount of rain utilised where it falls that there is a considerably greater surplus of unused rainfall after clearing than before. If subsoil conditions permit, this water seeps to lower levels, dissolving salt as it goes. Should this seepage water be forced to the surface by the presence of any impervious soil horizon such as a clay bar, then a moist area appears. As continued evaporation at the surface removes the water where it breaks out, a salt accumulation gradually develops. Thus



A small valley in which a rising saline water table has caused death of vegetation and severe salt encroachment

the essential factor for this type of problem is seepage water being forced to evaporate at the surface. Such a problem can develop even with comparatively fresh water.

2. Valley Waterlogging: Much of the unused rainfall moves downward beyond the root zone, seeping to lower levels. It may not necessarily break out on the hillside to give a seepage problem, but may continue to seep down into the valleys as underground water, and may ultimately enter the rivers as seepage. But if the movement into a valley is faster than underground movement from it, an underground accumulation of this water can take place. In this way watertables can be gradually brought closer to the surface. When the water is six or seven feet from the surface it is able to rise by capillarity, and on evaporation at the surface a salt encrustation remains.

Many of the broad flat valleys which were once active river systems of Western Australia are affected by valley waterlogging. The substantial reduction in gradient from the sloping land compared to the valleys is believed to be partially responsible for the build up of underground water in the valleys. Another contributing factor is the relatively shallow granitic bedrock. In some wheatbelt districts large areas of the most fertile soils have become so affected.

Flooding of the surface is often thought to be a cause of rising watertables. While this may be a contributing factor it is by no means the major one. Detailed studies of underground water movement have been conducted in many of the valleys of Western Australia and these studies have shown that the watertables arise primarily from underground seepage from the higher country into the valley, and not from flooding. However, because it destroys plant cover, flooding does help the upward movement of salt from the subsoil to the surface.

TYPE OF SALT

All salt-affected soils in Western Australia are characterised by a high level of soluble salts. In addition, all salt-affected clay soils also have a high level of sodium in the exchangeable cations. Approximately three-quarters of the affected soils could be classified as saline alkali.

PREVENTION OF SALT ENCROACHMENT

As a result of considerable experimentation in Western Australia three main principles have been shown as important in the handling of saline soils.

- (1) Grazing control.
- (2) Suitable cultivation.
- (3) The use of salt tolerant plants.

1. Grazing control is the most important single factor in the re-establishment of plant cover on affected soils. Completely bare areas will colonise with natural salt tolerant plants if grazing protection is imposed. While many of these plants are not very useful or productive they do enable many more useful plants to subsequently become established.

2. Suitable cultivation under Western Australian conditions is important for two reasons. Firstly, the cultivation allows rain penetration by breaking the surface seal which readily develops on affected soils. Without water penetration one cannot reduce the high surface salt concentration which develops. It is extremely difficult for germination to occur without this reduction in soluble salts at the surface. Secondly, cultivation leaves a roughened surface which traps seeds which would otherwise be blown off the wind-swept bare areas.

3. Salt tolerant plants: The choice of plants for salt land in Western Australia depends on many factors, such as rainfall, type of salt affected land and severity of encroachment. In general, however, one can summarise the position as follows:—

For seepage areas which remain moist throughout the year the most successful plant is the summer growing *Paspalum vaginatum* which is an herbaceous perennial. Winter growing species such as Wimmera ryegrass (*Lolium rigidum*) can also be quite useful.

For mildly affected areas of either the dry land salt or the valley waterlogging type one can, by persistent cultivation and sowing, re-establish a normal plant cover and reduce the high surface concentration of salt. These areas can then be returned to their normal crop rotations.

For severely affected areas it is not economic to attempt to return the land



An extensive area of "dry land" salt, once completely bare, being colonised with bluebush (*Kochia brevifolia*).

to its former use. Such areas are more suited to the sowing of a perennial salt tolerant plant which does not require repeated cultivation and sowing. A productive salt tolerant perennial such as bluebush (*Kochia brevifolia*) which also has the capacity to spread rapidly, is particularly suited to such conditions.

The use of bluebush in particular has made salt land reclamation on some of the severely affected soils a very attractive economic proposition.

References on Salt Land Reclamation:

Aspects of salt land reclamation and management are dealt with more fully in bulletins 2324, 2400 and 2630, obtainable

from the Department of Agriculture. These bulletins have been reprinted from the references quoted below.

- Burvill, G. H., and Marshall, A. J.—*Paspalum vaginatum* or Sea Shore *Paspalum*. Jour. of Agric., W.A., June, 1951.
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POTASSIUM DEFICIENCY

IN MEDIUM RAINFALL AREAS

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IT is well known that potassic fertilisers must be used for the successful growth of subterranean clover (*Trifolium subterraneum* L.) on many soils in the higher rainfall districts of Western Australia. Recent investigations have shown that some soils in medium rainfall districts are also too low in potassium to grow healthy subterranean clover pastures.

During the past five years potassium deficiency in subterranean clover has been recorded from a number of widely separated districts in medium rainfall areas (see map) in some cases on isolated soils only but in others over extensive areas. The affected soils have been mainly sandy surfaced and gravelly types, although in one case Dwalganup subterranean clover growing on a brown sandy clay was affected.

In this period, evidence of potassium deficiency has been obtained from the Eneabba, Watheroo, Wannamal, Bolgart, Bulyee, Wongan Hills, South Caroling, Wagin, Ongerup, Jerramungup and Gairdner River districts.

REASONS FOR POTASSIUM DEFICIENCY

Potassium deficiency of subterranean clover usually occurs on soils which have low potassium contents in the virgin state.

A summary of the analyses of soils obtained from various districts is given in Table 3, at the end of this article. The figures show that the levels of potassium present in many of our virgin soils are extremely low. On the other hand, the levels in some, such as the heavy soils in

the broad wheatbelt valleys, are adequate to cover any demands of farming.

Dwalganup subterranean clover develops symptoms of potassium deficiency in many soils which contain less than 80 lb. of exchangeable potassium in the top three inches of an acre of soil (0.2 milli-equivalents per 100 grams of soil) unless the subsoil reserves are within reach of the plant roots and are significantly higher in potassium. [Exchangeable potassium is that part of the potassium in the soil which is readily available to plants.]

The analyses show that large tracts of country in the Eneabba and Jerramungup-Gairdner River districts have low reserves of potassium. Since potassium deficiency occurs at Eneabba, it can be expected that large areas of the Western Sandplain will be affected. Much of the land between Ongerup and Ravensthorpe also has a low level of potassium.

Farming practices which remove substantial quantities of potassium from a soil can aggravate a naturally low soil potassium level, and can even induce potassium deficiency on soils which are naturally well supplied with potassium.

Hay cutting is particularly severe on soil potassium reserves. A ton of hay will remove 20 to 25 lb. of potassium per acre, equivalent to 40 to 50 lb. of muriate of potash.

Most of the potassium in pasture eaten by animals is returned to the soil; 80 per cent. of it in the urine and the remainder in the dung. Potassium therefore tends to be concentrated in camping areas and around watering points, and the general level falls in the rest of the paddocks. This can induce deficiency on land which is low in potassium.

SYMPTOMS OF POTASSIUM DEFICIENCY IN SUBTERRANEAN CLOVER

Potassium deficiency of subterranean clover is most readily diagnosed in the late spring, at the time of most rapid growth of pasture.

The leaves of affected clover plants show variable but nevertheless recognisable symptoms.

In the Dwalganup (early) strain, the leaf surfaces develop a fine spotting, and a characteristic scorching of the margins. The symptoms usually become obvious one or two weeks before flowering. The leaf colour may remain green, or in severe cases the leaves may become quite yellow.

A typical potassium deficiency of Dwalganup subterranean clover is shown in Fig. 3 on the colour plate (opposite page 768). With acute potassium deficiency, leaf size is very markedly reduced.

The symptoms on Dwalganup can easily be mistaken for those of drought. As shortages of both moisture and potassium occur in spring, many cases of potassium deficiency have undoubtedly been put down to drought.

The midseason strains, such as Bacchus Marsh and Mount Barker show somewhat different symptoms. In these varieties, the leaves pale from the edges and turn a dull yellow. A fine spotting then develops on the leaf surface. These spots can join up to give dead areas which can often be mistaken for insect damage. Where the deficiency is severe, the leaves are small and dull yellow. Colour plate Fig. 4 shows typical symptoms on a Midseason subterranean clover plant.

The Yarloop strain, like Dwalganup, shows a more marked scorching of the

edges of the leaves than is the case with the other midseason strains.

In all strains, the older leaves show the symptoms while the young leaves generally appear quite healthy. Finally, the older leaves scorch completely and die rapidly.

On a plant showing typical potassium deficiency, a single runner will show symptoms varying from complete scorching of the older leaves to apparently healthy young leaves near the growing point.

Chemical analysis of plant material can be used to confirm suspected potassium deficiency. At flowering, dried subterranean clover should contain at least 0.8 per cent. of potassium in the leaf and leaf stem if maximum growth is to be attained. In table 4 at the end of the article are listed results of some analyses of leaf material containing less than this. The table also gives the locations and soils on which the plants from which these samples were taken were grown.

SOME PLANTS ARE AFFECTED MORE THAN OTHERS

Subterranean clover is susceptible to potassium deficiency and is perhaps the best indicator plant of the common crops and pastures. Grasses and cereal crops are relatively unaffected. Deep rooted legumes, such as lupins and serradella (*Ornithopus sativus*. Brot.) do not appear to be as sensitive to potassium deficiency as subterranean clover.

One of the alternative methods of overcoming potassium deficiency is to plant these deep rooted legumes. For example, lupins are well-known for their ability to thrive on soils where the deficiency limits the growth of subterranean clover. Lucerne (*Medicago sativa* L), with its deep and extensive root system, grows satisfactorily on many deep sandy soils without developing potassium deficiency, while subterranean clover growing beside it is acutely affected. *Serradella* has also been successful on some deep sandy soils where subterranean clover has failed. Rose clover (*Trifolium hirtum*) appears to have a deep root system and may also be satisfactory, but as yet we have no evidence of this.

In at least some circumstances there are also marked differences in the productivity of different strains of subterranean clover



Fig. 1. Pasture growing on a soil supplying only a small amount of potassium. Capeweed (*Cryptostemma triste*) grass and *Erodium botrys* have obtained sufficient potassium to make reasonable growth but only a poor stand of subterranean clover has been produced



Fig. 2. This area adjacent to that in Fig. 1, has been treated with potash. The growth of subterranean clover has been greatly increased but the capeweed, grass and erodium have not been affected

In each picture the bare area has recently been cut to measure pasture yield and composition

on soils low in potassium. In the south Gairdner River area, Bacchus Marsh is less affected by low potassium levels than Dwalganup. While this could be partly due to differences in maturity, more production is obtained from Bacchus Marsh under these conditions, and the strain does not show symptoms of potassium deficiency.

No consistent increase in yield of cereal grain due to application of potassic fertiliser has ever been reported for any soil in the agricultural areas of Western Australia.

Potassic fertiliser should not, therefore, be applied to cereals.

This expensive fertiliser should be reserved for subterranean clover pastures known to be deficient in potassium.

VALUE OF POTASSIC FERTILISERS

Potassium should be important where the deficiency is severe enough to greatly reduce the density of the legume on a particular soil type.

A dense clover stand improves soil fertility and permits grasses to make better autumn growth than on less fertile soils. Where potassium deficiency is severe enough to reduce seed set, it will be an economic proposition to use potassic fertilisers even though above ground production is not greatly increased.

POTASSIUM CAN BE INFLUENCED BY SUPERPHOSPHATE

Research by Eastern States workers (1) has shown that as the amount of organic matter in the soil is built up by the growth of subterranean clover, the amount of available potassium is also increased.

This potassium is made available to the growing plants by weathering of minerals in the soil and is then retained in an available form by the soil organic matter.

On newly cleared land in Western Australia, the rate of superphosphate used largely determines the growth of subterranean clover pastures, and the organic matter increase is roughly proportional to the growth of the subterranean clover. High phosphate levels should therefore increase the rate of organic matter build up and could at the same time increase the level of available potassium in the soil.

However, in one experiment at Wongan Hills it was shown that with a high superphosphate application, the calcium contained in the calcium phosphate and gypsum of the super was antagonistic to potassium uptake. Figures in the following table demonstrate this effect.

WONGAN HILLS RESEARCH STATION

Effect of Increasing Rates of Superphosphate on Levels of Calcium (Ca) and Potassium (K) in the Leaves and Petioles of Dwalganup Subterranean Clover.

Rates of superphosphate.	Dry yield of tops (cwt./ac.).	% K	% Ca
0	28.6	1.76	1.33
20	33.0	1.87	1.34
40	33.9	1.52	1.43
60	33.8	1.49	1.49
80	34.3	1.24	1.63
120	35.8	1.33	1.56
240	33.5	0.88	1.78

L.S.D. 5% = 2.3

EXPERIMENTS USING POTASSIUM ON SUBTERRANEAN CLOVER PASTURES

Officers of the Department of Agriculture have carried out over 50 experiments with potassic fertiliser in medium and lower rainfall areas, and at only four sites have consistent increases in growth been obtained.

The results of these experiments are shown in Table 1.

At three other sites, growth increases have been obtained for one year only and no differences have been noted in subsequent years, even though additional potassium has been applied. The results of these experiments are given in Table 2.

At a number of other sites, the application of potassium to subterranean clover showing symptoms of the deficiency has not increased growth significantly.

Eneabba:

At Eneabba, soils in which the sand is deeper than two feet occur both on the hill slopes and the flats. In both locations soil potassium is low, but application of potassic fertiliser is likely to be useful only on the flats.

These deeper sands on the poorly drained flats grow excellent subterranean clover pasture in the first two years, but potassium deficiency is likely to develop in the third year. In an experiment on this soil type (see Table 1) application of potassium in the third year gave a 30 per cent. increase in yield of pasture. It seems that it will be profitable to apply potassium to subterranean clover pastures growing on this soil. Although not found extensively in the district this is the main soil type on a number of farms.

On the deeper sands of the freely-drained hill slopes, subterranean clover will not grow satisfactorily even with adequate nutrition (superphosphate, potash, copper, zinc, manganese and molybdenum) but the West Australian blue lupin (*Lupinus digitatus* Forsk.) grows well, provided superphosphate is used liberally. The West Australian blue lupin does not require additions of potassium when growing on this soil. Because of moisture shortage, only deep-rooted species are likely to grow satisfactorily on these areas, and such species are also likely to escape potassium deficiency. It is therefore unlikely that

potassic fertilisers will play an important part in the development of this soil.

Gairdner River and Jerramungup:

Subterranean clover showing potassium deficiency has been noted over a large area in these districts. The increase in growth obtained at Jerramungup (Table 2) followed a dry period and appears to have been associated with the greater drought resistance of the potassium treated plants.

In mixed swards of the Bacchus Marsh and Dwalganup strains, deficiency symptoms are seen only on the Dwalganup. As much of the Gairdner River area can grow the Bacchus Marsh strain satisfactorily, and as the deficiency is not generally acute, it is unlikely that it will be necessary to use potassium unless large amounts are removed or transferred by practices such as hay cutting.

Wongan Hills:

Symptoms of potassium deficiency have been observed on subterranean clover growing on both the yellow loamy sand and the better class sandplain. These symptoms are not seen every year, and levels of potassium in subterranean clover are generally satisfactory.

Newdegate:

Application of potassium to subterranean clover growing on a coarse sandy soil overlying clay at shallow depth cured symptoms of potassium deficiency but did not greatly increase growth.

Other Districts:

The soil types on which both the Bolgart (Table 1) and Watheroo (Table 2) experiments were planted are deep sands on which an alternative legume should be grown instead of using potassium.

The experiment at Lime Lake was carried out on a soil type which extends eastward almost to the Katanning-Dumbleyung road and grows subterranean clover satisfactorily when potassium fertiliser is used. Subterranean clover also grows well where potassium is applied to the soil type used in the Borden experiment.

Following these results a Borden farmer, Mr. Ian Duncan, has demonstrated that potassium can increase clover growth on

his property even where the clay is at the surface, although the response becomes greater with increasing depth of sand over clay. It should be profitable to apply potassium to subterranean clover growing on these soils.

RECOMMENDATIONS

Experimental results indicate that there is no real advantage from using more than 56 lb. per acre of muriate of potash on subterranean clover pastures growing in medium rainfall districts. Due to the shortage of moisture in spring there is often little increase in growth when potassium is applied to potassium deficient subterranean clover.

On many potassium deficient areas, particularly deep sandy soils, deep rooted species should be considered as an alternative to subterranean clover. Plants such as lupins, lucerne and serradella have a greater ability to obtain potassium from these soils and also tolerate the unfavourable moisture levels in the surface layers during dry periods.

Cereal crops do not normally respond to added potassium under Western Australian conditions. Potassium should therefore only be applied to potassium-deficient subterranean clover pastures

Muriate of potash should be used in preference to sulphate of potash, as sulphate of potash is a dearer source of potassium.

Residual Value:

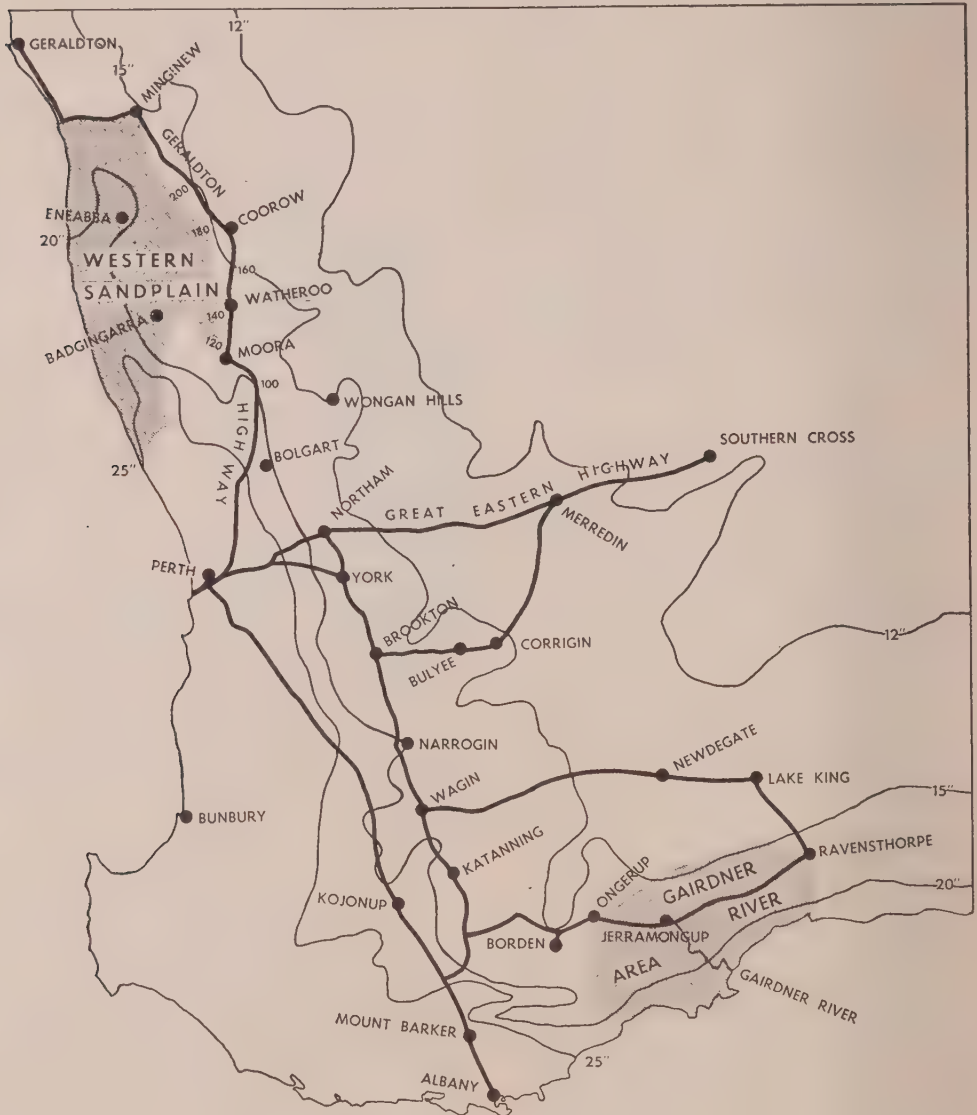
Under conditions where rainfall is not high, and where soil organic matter is being rapidly increased, it is unlikely that potassium will be rapidly leached. One application should last for a considerable time, unless potassium is removed or transferred by hay cutting or grazing stock.

In the experiments at Borden and Lime Lake (Table 1) there was a marked residual effect of the 1959 potassium applications. At both sites, 56 lb. per acre of muriate of potash applied in 1959 gave equal yields to 56 lb. per acre applied in 1960. Both treatments yielded 50 per cent. more than the areas which did not receive potassium.

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SOUTH-WESTERN AUSTRALIA

Showing places referred to in the text. The "medium rainfall areas" are those between the 15 and 25 inch isohyets
Shaded areas are largely composed of undeveloped sandplain soils, many of which are low in potassium



Fig. 3.—Potassium deficiency in Dwalganup subterranean clover. These leaf markings are seen when the deficiency is not acute. The leaflets are small and are dark green in colour except for their tips where there is a pale brown dead patch on each side of each leaflet. Note the similarity between these plants and those attacked by insects or affected by dry weather.



Fig. 4.—Potassium deficiency in Mount Barker subterranean clover. Note the small yellow green leaflets spotted mainly at the edges. In some leaflets the spots of dead leaf have joined together and the edges are completely dead. The spotting on the leaves can easily be mistaken for insect damage.

APPENDIX

Below are tabulated results of experiments (referred to in the text) in which responses to the application of potassic fertilisers have been recorded, as well as soil and plant analyses from a number of districts in the medium rainfall areas.

These tables provide a general guide to the likely occurrence of potassium deficiency on a particular soil type.

However, soil analysis by itself is not always a reliable guide to plant performances, and low soil potassium figures for any particular soil in table 3 should not be taken as a certain indication that subterranean clover pastures on that soil will need potassic fertiliser.

TABLE 1

EXPERIMENTS IN WHICH SUBTERRANEAN CLOVER SHOWED LARGE AND CONSISTENT RESPONSES TO POTASSIUM

Locality	Rate of Muriate of Potash	Dry Weight Yield of Clover	Dry Weight Yield of Pasture other than Clover	Total Dry Weight Yield	Soil Type
	lb./ac.	cwt./ac.	cwt./ac.	cwt./ac.	
Borden	<i>nil</i>	9	14	23	{ 0-5" grey sand. 5-8" white sand. 8-13" yellow sand. 13" orange brown mottled clay.
	56	18	12	30	
	112	23	13	36	
	168	25	12	37	
Lime Lake	<i>nil</i>	15	20	35	{ 0-2" grey sand. 2-14" white sand. 14-22" yellow sand. 22" loamy sand with soft gravel.
	56	20	20	40	
	112	23	22	45	
	168	29	22	51	
Bolgart	<i>nil</i>	11	10	21	{ 0-4" grey sand. 4-36" white sand.
	224	21	8	29	
Eneabba	<i>nil</i>			26	{ 0-2" grey sand. 2-20" white sand. 20" orange yellow clay.
	168	....	....	35	
	(applied in August of the sampling year)	....	....		

TABLE 2

EXPERIMENTS IN WHICH SUBTERRANEAN CLOVER SHOWED
A SIGNIFICANT RESPONSE TO POTASSIUM FOR ONE
SEASON ONLY

(All areas had received super, copper and zinc)

Locality				Rate of Muriate of Potash	Yield of Dry Clover and Grass
				lb./ac.	cwt./ac.
Watheroo ....	....	....	....	0	12
				20	13
				90	17
				180	19
Bulyee ....	....	....	....	0	28
				224	37
Jerramungup ....	....	....	....	0	16
				112	18

TABLE 3—POTASSIUM CONTENT OF SOILS

RESULTS OF ANALYSES FOR TOTAL AND EXCHANGEABLE POTASSIUM ON
SELECTED SOILS

(Dwalganup subterranean clover may develop deficiency symptoms at levels below 0.2 milli-equivalents of exchangeable potassium per 100 grams of soil)

District	Soil Description	Vegetations	Depth Sampled	Total Potassium Content*	Chemical Data. Exchangeable Potassium	Is the Soil Extensive in the District ?
			inches	%	milli-equiv.† per 100 grams	
‡49 miles east of the Gairdner River	Grey gritty sand	Mallee and low scrub	0-4	0.01	0.05	Yes
	Light grey gritty sand ....	.....	4-9	0.01	0.05	
	Grey and brown mottled gritty clay	.....	10-15	0.08	0.02	
	Light grey rusty mottled gritty clay	.....	15-18	0.09	0.025	
‡51 miles east of the Gairdner River	Brown gravelly loamy sand	Mallee and low scrub	0-3	0.03	0.1	Yes
	Yellow-brown gravelly sand	.....	3-15*	0.03	0.1	
	Yellow-brown and grey mottled gravelly sandy clay	.....	15-20	0.14	0.3	
‡54½ miles east of the Gairdner River	Brown gravelly sand with quartz grit	Mallee and low scrub	0-4	0.03	0.1	Yes
	Red-brown gritty clay	.....	4-12	0.12	0.2	
South Gairdner River	Gravelly sand	Mallee and low scrub	0-14*	0.01	less than 0.1	
	Brown clay	.....	14-20	0.14	0.5	
South Gairdner River	Gravelly sand	.....	0-13	0.01	less than 0.1	
	Pale brown clay	.....	13-20	0.02	0.1	
Jerramungup	Grey sand	Mallee and low scrub	0-3	0.01	....	Yes
	Red-brown clay	.....	9-12	0.03	....	
Jerramungup	Red-brown clay	.....	24-	0.06	....	
	Grey sand	Mallee	0-6	0.01	0.1	
Jerramungup	Brown clay	.....	6-12	0.08	0.1	
	Sandy gravel overlying gritty clay	Mallee	0-2	0.06	0.1	
Jerramungup	Red-brown clayey sand over sandy clay at 6"	||Yate	2-12	0.13	0.2	Yes
		.....	0-6	0.17	0.2	
§Ongerup	Grey sand	Mallee and low scrub	6-12	0.21	0.1	Yes
		.....	0-5	0.005	less than 0.05	
	White leached sand	.....	5-8	0.010	less than 0.05	
	Yellow sand	.....	8-13	0.017	0.05	
	Orange-brown mottled sandy clay	.....	13-	0.071	0.10	
	White sand	||White gum	0-2	0.01	0.1	
Katanning	Grey gritty clay	.....	2-12	0.06	0.2	Yes
	Grey loamy sand	||Sheoak with some white gum	0-2	0.03	0.2	
Wagin ....		.....	2-12	0.03	0.2	
	Grey loam + organic matter	||Jam and ||York gum	0-6	0.08	0.5	
Wagin	Grey sandy clay	.....	6-12	0.09	0.3	
	Dark grey loamy sand	Sheoak with some jam	0-4	0.03	0.2	
Wagin	Yellow-grey loamy sand	.....	4-12	0.02	0.1	
	Gravelly sand	Heath association, odd Xmas tree and sheoak	0-3	0.01	less than 0.1	
§Wagin	Yellow sand	.....	4-12	0.01	less than 0.1	Yes
	Grey sand	||Banksia and low scrub	0-2	0.01	0.1	
	Leached white sand	.....	2-14	0.009	0.05	
	Yellow sand	.....	14-22	0.014	0.15	
	Loamy sand with ferruginous concretions containing quartz fragments	.....	22-	0.042	0.30	

TABLE 3—continued

District	Soil Description	Vegetations	Depth Sampled	Total Potassium Content*	Chemical Data. Exchangeable Potassium	Is the Soil Extensive in the District ?
			inches	%	milli-equiv.† per 100 grams	
Wagin	Grey sand	Whitegum, she-oak	0-6	0.02	0.1	
Bindoon	Brown sand Brown sandy gravel ....	||Marri (red gum), jarrah	6-12 0-2	0.01 0.02	0.1 0.1	Yes
Wannamal	Yellow sandy gravel Grey-brown loamy gravel	Whitegum, marri (red gum)	2-12 0-2	0.02 0.04	0.1 0.2	Yes
94-mile Peg, Great North-ern Hwy.	Yellow-brown loamy gravel Light brown gritty loam Very light brown gritty loam	Whitegum	2-9 0-1½ 1½-12	0.04 0.06 0.05	0.1 0.1 0.1	Yes
98-mile Peg, Great North-ern Hwy.	Brown gravelly sandy loam Yellow-brown gravelly clay	Whitegum	0-3 3-12	0.04 0.05	0.2 0.1	Yes
South Caroling	Grey sand Loose gravel and sand		0-2 15-18	.... ....	0.05 0.05	
114-mile Peg, Geraldton Hwy.	Fine red-brown sand Red-brown clay ....	||Salmon gum	0-5 5-13	0.09 0.23	0.2 0.4	Yes
140-mile Peg, Geraldton Hwy.	Pale grey-brown gravelly loam Pale grey-brown gravelly loamy sand Pale grey-brown gravelly clay	||Salmon gum, ||York gum	0-8 8-12	0.07 0.06	0.2 0.2	
159-mile Peg, Geraldton Hwy.	Yellow sand ....	||Native pear, banksia	12-20 0-4	0.13 0.01	0.4 0.1	Yes
169-mile Peg, Geraldton Hwy.	Dark yellow sand Grey-yellow sand ....	||Native pine, banksia, some ||tamma	4-12 0-3	0.01 0.01	0.1 0.1	Yes
Eneabba	Brown-yellow sand Grey-white sand	Low sand plain scrub	2-12 0-9	0.02 0.01	0.1 0.1	Yes
Ongerup	White-yellow sand Orange loamy sand Grey soil ....	||Yate	9-20 20-26 0-4	0.01 0.04 0.10	0.1 0.1 0.3	
Ongerup	Grey soil + gravel ....	||Gimlet and mal-lee	4-12 0-6 6-12	0.26 0.74 1.03	0.8 2.0 2.9	
Gnowangerup...	Grey clayey sand Brown clay		0-4 4-12	0.12 0.09	0.8 0.8	
Katanning	Red-brown clay Red-brown clay		0-2 2-12	0.52 0.75	1.4 1.7	
Wagin	Red-brown loam	Jam with some York gum	0-5	0.29	1.0	
Wagin	Red-brown cemented loam Brown-grey sandy clay	Whitegum, jam, York gum	5-12 0-3	0.35 0.14	1.1 0.5	
Wagin	Tough sandy clay Brown loam	Jam and some sheoak	3-12 0-6	0.24 0.13	0.5 0.5	
Bindoon	Brown loam (granite at 12") Red-brown clay loam Red-brown clay loam	York gum	6-12 0-3 3-12	0.12 0.20 0.13	0.3 0.5 0.4	Yes
106-mile Peg, Geraldton Hwy.	Dark brown gravelly loam Light brown gravelly loam	York gum	0-2 2-12	0.21 0.12	0.7 0.2	

TABLE 3—continued

District	Soil Description	Vegetations	Depth Sampled	Total Potassium Content*	Chemical Data. Exchangeable Potassium	Is the Soil Extensive in the District ?
			inches	%	milli-equiv.† per 100 grams	
127-mile Peg, Geraldton Hwy.	Brown clay	York gum	0-3	0.31	0.7	Yes
	Red-brown loam .....	.....	3-8	0.34	0.6	
	Red-brown clay .....	.....	8-14	0.41	0.8	
128-mile Peg, Geraldton Hwy.	Red-brown gravelly sandy loam	York gum .....	.....	0.29	1.4	Yes
	Red-brown gritty clay .....	.....	.....	0.64	2.1	
171-mile Peg, Geraldton Hwy.	Grey-brown loam	York gum, salmon gum	0-4	0.21	0.9	
	Grey-brown clay .....	.....	4-12	0.50	1.4	
186-mile Peg, Geraldton Hwy.	Grey-brown gritty clay	Salmon gum, gimlet	0-6	0.43	1.2	Yes
	Clay with lime at 6" .....	.....	6-12	0.40	0.9	
198-mile Peg, Geraldton Hwy.	Brown gravelly sand .....	||Tall tamma, some wattle||	0-4	0.11	0.4	
	Brown gravelly sand .....	.....	4-12	0.11	0.4	
Three Springs (heavy land to west)	Red-brown clay loam	Salmon gum, York gum	0-4	0.57	2.7	
	Dark red-brown clay loam ....	.....	4-12	0.70	2.2	

* Total Potassium content :—

Determined by Hall's Method of extraction with hydrochloric acid.
1% Potassium = 20,000 lb. per acre in each 6" depth of soil.

† Exchangeable Potassium content :—

1 milli-equivalent per 100 grams = 780 lb. of potassium in each 6" depth of soil over one acre.

‡ On Jerramungup-Ravensthorpe road.

§ Soils being farmed. All other samples taken from virgin land.

|| Native vegetation :—

Gimlet	=	<i>Eucalyptus salubris</i> . F. Muell.
Yate	=	<i>Eucalyptus cornuta</i> . Labill.
Moort	=	<i>Eucalyptus platypus</i> . Hook.
White Gum	=	<i>Eucalyptus redunca</i> Schau. var. <i>elata</i> . Benth.
Salmon Gum	=	<i>Eucalyptus salmonophloia</i> . F. Muell.
York Gum	=	<i>Eucalyptus loxophleba</i> . Benth.
Jarrah	=	<i>Eucalyptus marginata</i> . Shr.
Marri (Red Gum)	=	<i>Eucalyptus calophylla</i> . R. Br.
Xmas Tree	=	<i>Nuytsia floribunda</i> (Labill). R. Br.
She Oak	=	<i>Casuarina huegeliana</i> . Mig.
Jam	=	<i>Acacia acuminata</i> . Benth.
Native Pear	=	<i>Xylomelum angustifolia</i> . Kippist.
Native Pine	=	<i>Callitris preissii</i> Mig. spp. <i>verricosa</i> (A. Cunn. ex Endl.). J. Gardin.
Banksia	=	<i>Banksia prionotes</i> . Lindl.
Wattle	=	<i>Acacia</i> spp.

TABLE 4—POTASSIUM CONTENT OF LEAF SAMPLES

RESULTS OF 15 SAMPLES, SHOWING PERCENTAGE POTASSIUM ON DRY WEIGHT BASIS
(Where Content is less than 0·8%, Plant is Potassium Deficient)

District	Location	Soil Type	Vegetation	Potassium Content	Is this an Extensive Soil Type ?
Eneabba	Block 4 : 3rd Year Clover South Exp. Area	Grey sand over yellow sand ; orange loamy sand at 20"	Low and plain scrub	0·22	Yes
		Grey sand over yellow sand ...	Low sand plain scrub	0·30	Yes
	Block 8	Gritty sand	*Blackbutt and low scrub	0·29	No
	Block 8	Grey sand over yellow-brown clay	Low sand plain scrub	0·41	No
	Block 8	Gravelly sand	*Blackboy and low scrub	1·69	Yes
Gairdner River	Block 5	Coarse grey sand over brown clay	Mallee and low scrub	0·57	Yes
	Block 89	Grey sand over deep white sand	*Banksia and low scrub	0·36	No
Jerramungup...	Block 1257	Coarse grey sand	.....	0·33	No
	Block 1259	Grey sandy clay	*Moort mallee	0·39	Yes
Watheroo	H. Scott	Grey sand over yellow loamy sand	Banksia	0·49	No
Bolgart	P. Syred	.....	.....	0·60	No
Borden	L. Miller	Grey sand over brown clay	.....	0·79	Yes
Beverley	Avondale R.S.	Grey sand	.....	0·45	No
Talbot Brook...	York Road	Grey brown sand ; light grey-brown mottled sand	Jam and sheoak	0·49	Yes
Mingenew	E. Smart	Deep yellow loamy sand	Wattle and low scrub	0·33	Yes

* Native Vegetation :—

Banksia = *Banksia prionotes*. Lindl.
Blackbutt = *Eucalyptus tottiana*. F. Muell.
Blackboy = *Xanthorrhoea preissii*. Endl.
Moort = *Eucalyptus platypus*. Hook.
Jam = *Acacia acuminata*. Benth.
Sheoak = *Casuarina huegeliana*. Mig.

RESEARCH STATION FIELD DAYS—CEREAL AND SHEEP AREAS

The usual round of field days will be held on the Department of Agriculture's research stations in the cereal and sheep areas this year. Pasture field days have already been held at Wongan Hills and Merredin Research Stations.

The research station field days this spring will be:

SALMON GUMS—Friday, September 15.

CHAPMAN—Wednesday, September 20.

AVONDALE—Tuesday, September 26.

BADGINGARRA—Wednesday, September 27.

ESPERANCE—Friday, October 13.

NEWDEGATE—Wednesday, October 18.

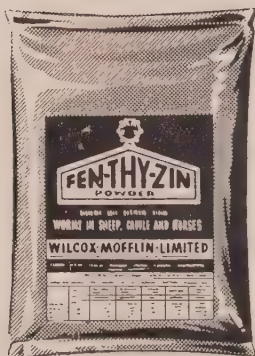
MERREDIN (Cereals)—Tuesday, October 24.

WONGAN HILLS (Cereals)—Thursday, October 26.

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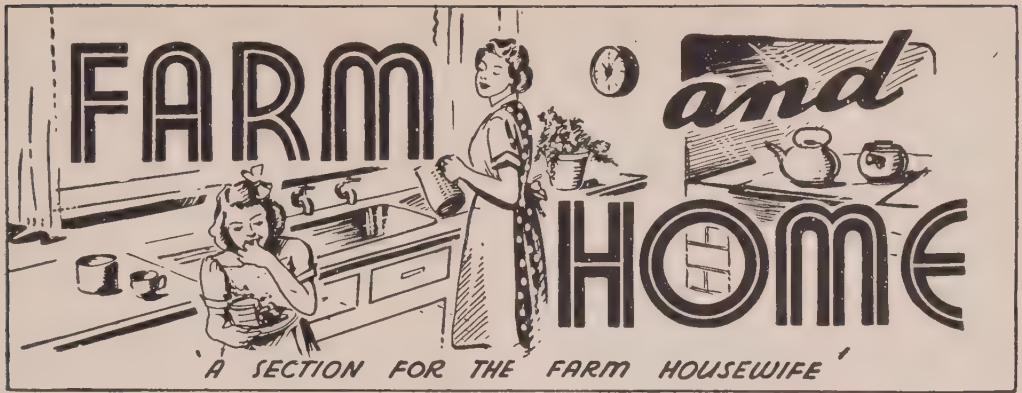
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F-T-Z. 6



That Prize-Winning Fruit Cake

By HELEN M. GLOSTER

IT is the ambition of most women to make the perfect fruit cake. Some try over and over again, hoping that some day they will produce a prize-winning cake.

People often wonder, when viewing exhibits in a Show, why exhibit "A" was awarded first prize while exhibit "B," which looks so much better, was passed over.

Many points are taken into consideration by the judges. If intending exhibitors examine each of these in turn they will be able to see where some of the marks have been lost.

The General Appearance is the first thing that catches the judge's eye. She will look for a rich, well-baked cake, rich brown in colour, well shaped, and attractively served.

The Shape of the Cake:

The sides and underneath of the cake should be the same shape as the tin. The top should be *very slightly rounded* with an unbroken surface.

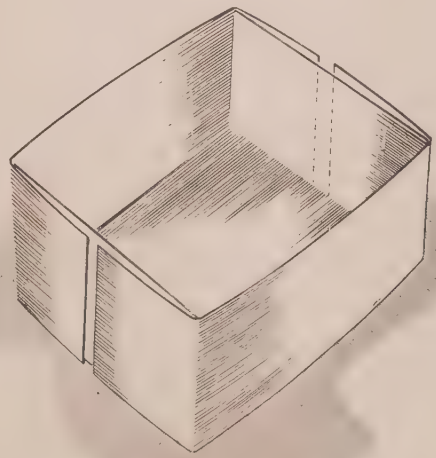
A cake which bursts or cracks on the top has usually been in too hot an oven.

Bursting is also sometimes caused by too much self-raising flour in the mixture. One part by weight of self-raising flour to four of parts plain flour is enough for a rich fruit cake.

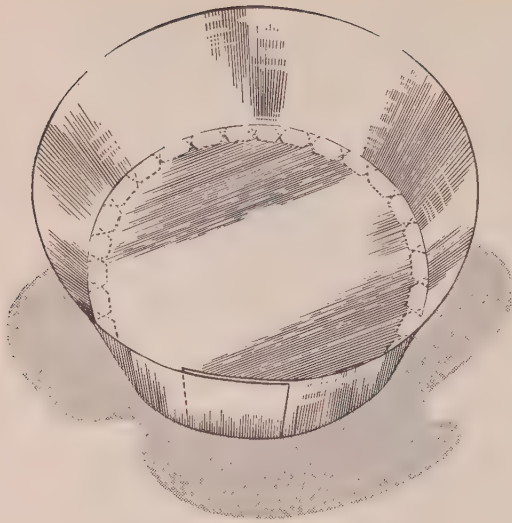
The tins must be carefully lined with paper. A big cake should have three layers

of brown paper and an inner layer of greaseproof paper.

See that lining paper fits closely against the tin. A dent in the paper will cause a dent in the cake, spoiling the appearance. These layers protect the surface, preventing it from becoming too brown. Some



Neatly cut paper lining for a square cake tin.



Paper lining cut for a circular tin.

cake makers put a double sheet of brown paper across the top of the cake as well, to prevent over-browning.

To Cut the Lining Paper:

Cut layers of paper to fit the base of the tin. Remove a thin strip around the edge to allow for the thickness of the side lining paper.

Cut side lining paper to fit around the sides of the tin, with a slight overlap. The paper should reach beyond the rim after the tin is lined, and an extra inch should be allowed for folding and fitting under the base lining.

Take the side strips and fold over one inch along the lower edges. Slit with the scissors (slantwise), as illustrated.

Grease the greaseproof layer and line the tin, doing the sides before the base.

See that all lining paper is pressed well against the tin with *no dents*.

Lining paper is usually left on the cake until it is iced or until it is to be cut for eating.

All traces of paper should be removed before serving. Care is necessary in doing this as it is easy to break off a small piece of cake or a sultana in the process.

TO EXHIBIT A CAKE

The cake should be presented on a plate which is slightly larger than the cake. There should be a paper doyley on the

plate and there should be no stray crumbs in evidence.

Show stewards often make provision for cardboard plates and paper doyleys, but onus is on the exhibitor to see that the cake is well presented, and has a clean fresh appearance.

It is advisable to cover the whole exhibit with clear plastic or cellophane as a protection against dust and flies.

THE TEXTURE

The judge will then proceed to *cut* the cake and examine the texture, which should be fine and even. She will also sample the cake by tasting it. Although she does not know who you are, it is simply amazing what she will learn about you, and what goes on in your kitchen, in these brief minutes. Perhaps there are air-bubbles in the cake? This indicates the use of too much self raising flour, or that the mixture may not have been mixed together thoroughly.

The fruit should be distributed evenly through the mixture.

If the proportions of all ingredients are correct, the mixture when ready for the oven should be stiff enough to support the mixing spoon in an upright position. If the mixture is too moist, the fruit will sink while the cake is cooking.

Has the exhibitor removed all seeds from the raisins? Most cooking raisins are sold seeded, but there are always a few stray seeds. The best cooks always go over the raisins before adding.

Other dried fruits require thorough preparation. There are always stalks to be removed from sultanas, and some dried fruits have a certain amount of dust and grit adhering to them. This may be removed by rubbing on a cloth with a little plain flour, or washing the fruit and drying by rubbing on a cloth. If fruit is washed it is better to do this the day before the cake is mixed. On no account should the fruit be left standing in water, as it will absorb some of it, and make the cake too moist. Rubbing the fruit for drying also loosens the stalks, which may then be removed.

It is as well to dry the fruit near the stove before using. The hob of a wood stove is a good place to do this.

For a finely textured cake, the butter and sugar should be creamed thoroughly

until there is no trace of grains of sugar.

Eggs should be well beaten and added gradually to the creamed mixture. Thorough beating is necessary between each addition of egg.

Texture may be spoilt by too cool an oven, sudden opening and shutting of oven to produce an inrush of cold air, especially in the early stages of baking. The oven should not be in a draught, as this causes the temperature to fluctuate.

FLAVOUR

For good flavour all ingredients should be fresh and of the best quality. Perhaps the most difficult part of the whole process is knowing exactly how to select ingredients, and the amount of flavouring to use.

The following points should be useful in the selection of ingredients.

Fat:

First grade butter undoubtedly gives the best results. Farm butter, if used, should be freshly made. Although quite wholesome farm butter is inclined to develop a strong flavour which is sometimes evident in the cake after it has been kept for a while.

Eggs:

Fresh hen eggs, or eggs a few days old give the best results.

Sugar:

Raw or brown sugar is preferable to white sugar.

Nuts:

Almonds and not peanuts should be used in fruit cakes. Almonds may be left unblanched. The skins will not spoil the appearance of the cake and many cooks consider unblanched almonds give a better flavour to the cake.

Almonds and peel should be chopped finely so that flavours all blend evenly through the cake.

Essences:

Pure essences are stronger and give a better flavour than artificial ones.

Caution is needed to see that no one flavour of essence or spice predominates.

Cinnamon and other spices:

Use reliable brands.

Fruit cakes improve with keeping as it takes time for the flavours to blend.

Brandy or Rum added to the mixture improves the flavour and helps to preserve the cake if it is kept for any time.

Some cooks add the spirit to the mixture during the making.

Try pouring it slowly over the cake *after* baking when the cake has cooled. There is no loss by evaporation if this method is used.

BAKING THE CAKE

When putting the mixture into the tin, see that it goes well into the corners. Scoop the mixture out in the centre to make a hollow. This is to ensure a cake *slightly* rounded on the top when baked.

The most anxious time for the cook is when the cake goes into the oven.

If a wood stove is used the oven should be preheated to moderate heat, the cake put in at the bottom of the oven and cooked with a *gradually decreasing* heat.

If cooking in a gas or electric oven with a thermostat the oven is heated to 425° F.

This heat is reduced to 300° F. when the cake is put into the oven and further reduced to 275° F. during the cooking. The cake is baked in the lower part of the oven.

A large cake (1 lb. of each of the main ingredients) takes from five to six hours to cook. A smaller cake (half size) takes from three to four hours. The oven should be kept free from draughts, and it is better not to look at the cake during the first hour.

When opening the oven, open and close *gently* and only for enough time to see into the oven.

Leave the cake to cool in the oven before taking it out.

A GOOD RECIPE

A good fruit cake contains about one pound of each of the main ingredients. Here is a reliable recipe for such a cake:

Ingredients:

1 lb. butter.

1 lb. raw sugar.

10 eggs (20 oz.).

1 lb. plain flour.

$\frac{1}{4}$ lb. self-raising flour.

1 lb. currants, 1 lb. sultanas, 1 lb. raisins;

or 3 lb. mixed fruit.

- $\frac{1}{4}$ lb. almonds (shelled).
- 8 oz. mixed peel.
- 1 teaspoon each vanilla, almond and lemon essence.
- $\frac{1}{2}$ nutmeg grated.
- 1 level teaspoon cinnamon.
- 1 level teaspoon ground ginger.
- 1 level teaspoon crushed cloves.
- $\frac{1}{2}$ wineglass brandy or rum.

Method:

1. Prepare tin.
2. Prepare fruit, chop almonds and peel.
3. Cream butter and sugar.
4. Beat eggs. Add a small quantity at a time, beating well between each addition.
5. Add fruit and essences.
6. Sift in flour and spices and mix well.

7. Two-thirds fill a cake tin, scooping a hollow in centre of the cake.

8. Put into a moderate oven with a gradually decreasing heat.

9. Bake five to six hours.

10. Test the centre of the cake with a heated skewer. When cake is cooked, the skewer comes away clean.

11. Next day pour brandy or rum slowly over the cake.

CORRECTION

In the recipe for steak and kidney pudding in the June issue of the Journal, the words "make a hole in the cloth" should read, "make a hole in the crust."



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COTTON FIREWEED—A NATIVE WEED MENACE

By G. R. W. MEADLY, Officer in Charge, Weeds and Seeds Branch

INTRODUCED plants have provided most of our weed problems. Cape tulip, double gee and soursob come from South Africa, Saffron thistle, Paterson's curse, wild turnip and wild radish from Europe, mesquite from the southern United States and Bathurst burr from South America. The relatively few native plants which have become troublesome weeds include Afghan thistle and Sarsaparilla.

Another native plant which has gained unfavourable notoriety during the past two or three years is *Erechtites quadridenta* which, fortunately, has the more acceptable common name of cotton fireweed.

Cotton fireweed is a perennial species found naturally over an extensive area in temperate Australia and New Zealand, including the southern part of Western Australia. Although usually insignificant until the land is cleared, it then tends to multiply rapidly and dominate pastures, particularly in their early stages of development.

It is mainly a problem on lighter soils but does occur on some heavy land. The largest infestations are in the Jerramungup-Borden-Many Peaks area.

Clearing is often followed by a general increase in weed growth, which may include some native plants. Usually after cropping and establishment of pastures, however, these tend to become reduced. This has been the experience in some districts with cotton fireweed. For example, at the Esperance Research Station, it

appeared in quantity some years ago, but has decreased in significance as the pastures have developed.



A dense stand of cotton fireweed. If it reaches such proportions the weed can dominate pastures.

But in the Ongerup-Jerramongup area in particular, cotton fireweed is not following this pattern, and is increasing rather than decreasing in extent.

The rapid increase during the past two years can be attributed in part to favourable seasons, especially during the summer, but it is obvious that this tract of country is so well suited to the growth of the weed that we cannot rely on a natural decline and must look for some more positive control measure. A number of War Service Land Settlement properties are among the worst affected.

Cotton fireweed is a rather shallow rooted perennial which, under some conditions, may also grow as an annual or biennial. It is a rather compact plant, growing to a height of from two or four feet. The hairs on the narrow leaves and stems give it a generally grey appearance.

Numerous relatively small yellow, daisy-like flower heads are formed in a panicle. Each head gives rise to many seeds, with a pappus (or parachute attachment) which enables them to be carried long distances by the wind.

Officers of the Department of Agriculture and War Service Land Settlement have discussed the problem with settlers in the affected areas and possible control measures are being investigated. Trials include various rotations involving cultivation, cropping and pasture establishment, along with mowing, burning and the use of chemicals.

These are mainly long term treatments and, at this early stage, little information from them can be expected.

It is already obvious, however, that cotton fireweed is relatively resistant to chemicals, which have not given control at rates economical for large areas.

THE WILUNA GROUND WATER RESEARCH STATION

By D. G. WILCOX, Adviser, North-West Division, Wiluna

UNDERGROUND waters are cheap irrigation supplies. They don't need costly dams and diversion works for their exploitation, because they are available right at the farm site. And since they are stored underground they are not subject to evaporative losses, which can be over six feet a year in surface dams.

The Wiluna Ground Water Research station will use this type of water, from deposits very close to the old mining town. It will be one of the first irrigation stations in Australia using underground water.

While Wiluna has always been noted for its good water supply, irrigation supplies have not been suspected in other parts of inland Western Australia. However, a recent survey by the C.S.I.R.O., of an area around Meekatharra and Wiluna has indicated that water in sufficient quantities for irrigation is available over very wide areas. In fact their study has indicated that the Wiluna basin is really quite a minor one compared to some of the others located during the survey.

It will be the aim of the Wiluna Research Station to try to find means of exploiting this water to the best possible advantage.

EXISTING GRAZING INDUSTRIES

Probably the most immediately rewarding investigations will be those which will bolster up the existing sheep and cattle industry. This industry often suffers through periods of severe drought when sheep and cattle losses are high. Supplementary feeding for survival during periods of stress can help to avoid these often catastrophic losses. A very few properties have their own irrigation patches where these supplementary feeds are grown. It will be one of the tasks of the new station to improve on the production methods used, to inquire into new varieties which could be grown, and to develop feeding techniques for the best use of fodder, as well as to foster and encourage station owners to undertake their own irrigation schemes.

Mr. Wilcox inspects the outlet of part of an underground water supply which has been used to grow 20 acres of lucerne on a station in the Wiluna district. Hay produced here provides supplementary feed for sheep on inland stations.

Country in the background is typical of that on which the new research station will be established.



Most of the research work into supplementary feeding under desert range conditions has been along the lines of feeding for survival. There is a whole field of research into the feeding of sheep for maximum wool production, at all times, in the feeding of lambs and weaners for maximum development, in the feeding of pregnant ewes, and the fattening of cattle, which needs to be developed. We hope to be able to use some of the production from our irrigation trials in field experiments on these aspects of sheep and cattle management in arid areas.

COMMERCIAL CROPS

Investigations of a long term nature on the research station involve the examination of commercial crops. Already, peanuts and cotton have given promising yields and it is hoped that this line of work will extend to embrace crops such as castor oil, tobacco, dates and citrus fruits. This phase of the activities of the station will be concerned with testing types of crops and varieties in the early stages, and it is not expected that much will come of it for some years.

The indications are that the water supplies available are large enough to support some form of commercial cropping without endangering the demands of the sheep and cattle stations.

NATIVE PLANTS

Along-side these more or less expected lines of research we hope to be able to commence a study of the native plants of the area. The task of developing a proper grazing management scheme for pastoralists to follow has always been made difficult by the haphazard rainfall which limits the growth of the plants. It often takes years of intermittent growth before a plant matures. At the research station we hope to overcome these delays by growing the native plants under ideal conditions so that their various features can be recognised in a short time, then incorporated in range management trials.

With a plant introduction section, this part of the programme could develop into a major research project, the results of which could serve to assist workers in similar vegetation zones in Australia.

We hope that the programme which we will undertake at the Research Station will be well balanced. It covers the present and presumed demands of the existing industry and it provides for the development of a new industry based on commercial cropping.

Whatever industry proves most rewarding, it will be because of the exploitation of a new resource in inland Western Australia, its ground water.

ACETONEMIA IN DAIRY CATTLE

By J. CRAIG, Veterinary Surgeon

DESPITE differences in environment, dairy farmers all over the world are familiar with certain common ailments in their cattle. Calving troubles, infertility, mastitis, calf scours and metabolic disorders are found in all dairying districts.

The best known of the metabolic disease group is of course milk fever, which, before the advent of calcium treatment, was the No. 1 killer of freshly calved dairy cows.

Rather less prevalent but of extreme importance to the farmer endeavouring to maintain milk production, often under difficult conditions, is **acetonemia**.

Acetonemia has been recognised and accepted by farmers for many years as a vague type of condition which rarely causes death. Each year, and especially during the summer, a number of the best cows in a herd would become affected, and in some dairies even first-calf heifers might show symptoms of the disease.

The incidence of acetonemia rises sharply in December and remains quite high until March. About 90 per cent. of cases occur within the first six weeks after calving.

Symptoms:

In a typical case, a cow which has been milking well is suddenly noticed to be dull and without appetite and the milk yield falls quite markedly. Body condition is rapidly lost and affected animals appear to be weak and walk in a stiff, slow manner.

Constipation is common. There is however, no rise in the temperature of an affected animal.

In a few cases nervous symptoms are seen, the commonest of these being grinding of the teeth and sucking of the tongue. If left untreated, the cow slowly recovers her appetite after about two weeks, but only rarely does milk production return to its former high level.

In attempts to diagnose the disease, acetone testing tablets are useful, especially in cows showing little else than a sharp drop in the milk supply and a loss of appetite and condition. Farmers who

have had some experience with the disease often become quite adept in detecting the characteristic, sweetish smell of acetone in the breath and in the milk.

In few diseases has such an extensive repertoire of drugs been lavished on ailing cows in attempts to bring them back to normal health and production.

The modern veterinary approach to Acetonemia usually relies on hormones such as A.C.T.H. and cortisone; these are undoubtedly efficient but are very costly at adequate dosage levels. Other useful treatments involve daily subcutaneous injections of glucose, followed by drenching the cow with glycerine.

Yet another helpful drug is cobalt, which is known to simulate the rumen bacteria, and thus indirectly reactivates the animal's appetite. The old-fashioned mixture of ammonium carbonate and nuxvomica is still used to achieve a similar effect.

Most cases of Acetonemia occur soon after calving, and it is common practice to bring them straight in from a dry paddock at this time.

I suggest that the sudden change from such a paddock environment to bale feeding places an unnecessary stress on the freshly calved cow. It is far better to feed concentrates and some green feed, if this is available, for at least two weeks before the due date of calving. This procedure will allow the rumen bacteria to adjust to the change of diet.

I would also urge that concentrates be fed at high levels during the first six weeks after calving.

If these straight-forward management and feeding practices are carried out conscientiously, not only will the incidence of acetonemia in the herd be reduced, but increased milk production can be assured.